CRINOIDS FROM DEVONIAN LIMESTONES OF EASTERN AUSTRALIA

PETER A. JELL, JOHN S. JELL, BRIAN D. JOHNSON, RUTH MAWSON AND JOHN A. TALENT

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Crinoid material, often a significant constituent of many Devonian limestones in eastern Australia, includes calices of 26 taxa. A study of these taxa, based mainly on the calices is presented. The following new taxa are described: *Struszocrinus dulciculus* gen. et sp. nov., *Pandanocrinus martinswellensis* gen. et sp. nov., *P. gueriensis* gen. et sp. nov., *P. wellingtonensis* gen. et sp. nov., *Melocrinites tempestus* sp. nov., *Melocrinites solus* sp. nov., *Eucalyptocrinites fonzi* sp. nov., *Dolatocrinus peregrinus* sp. nov. and *Shimantocrinus distinctodorsus* gen. et sp. nov. The following six European Devonian species have been recognized and discussed: *Rhipidocrinus crenatus* (Goldfuss), *Hexacrinites interscapularis* Phillips, *H. spinosus* Muller, *Eucalyptocrinites rosacens* Goldfuss, *E. praerosaceus* Yakovlev and *Cupressocrinites abbreviatus* Goldfuss. A few incomplete or poorly preserved specimens are referred to Spyridiocrinid gen. nov., Carpocrinid indet., *Rhipidocrinus*? sp., Polypeltid indet., *Pandanocrinus* sp. cf. *P. wellingtonensis* gen. et sp. nov., *Parapisocrinus* sp., Gasterocomid sp., *Cupressocrinites* sp. cf. *C. gracilis* Goldfuss, Inadunate indet. Two indeterminate crinoids are briefly described.
☐ *Crinoids, Devonian, Eastern Australia.*

Peter J. Jell, Queensland Museum, PO Box 300, South Brisbane, Queensland 4101, Australia; John S. Jell, Department of Geology and Mineralogy, University of Queensland, St Lucia, Queensland 4067, Australia; Brian D. Johnson, Ruth Mawson, and John A. Talent, School of Earth Sciences, Macquarie University, Balaclava Rd, North Ryde, NSW 2113; 16 September, 1987.

Crinoidal skeletal fragments are common components of many Devonian limestones in eastern Australia but to date they have been recognized as disaggregated fragments usually of stems or more rarely of the crown. Alternatively they are preserved in massive clean limestones that extremely rarely fracture or weather to reveal the structure of the crinoid crown. Only four genera have been recognized previously in eastern Australian Devonian limestones (Philip, 1961; Bates, 1972) and two of these are doubtful assignments while a third is not specifically identifiable. It should be noted that two of these genera from the Early Devonian of Victoria, namely *Hexacrinites* and *Eucalyptocrinites*, are common among the faunas described below. Devonian crinoids from siliciclastic sediments are scarcely better known with only seven genera previously recognized (Bather, 1897; Chapman, 1903; Jell, 1982; Jell & Holloway, 1983). Over the last 10 years the senior author has studied Palaeozoic echinoderms particularly from Victoria (Jell, 1982; Jell, 1983; Jell & Holloway, 1983; Holloway & Jell, 1983), and a large fauna of Devonian crinoids remains to be described from fine sandstones and siltstones of the Melbourne Trough. The material described below has been assembled over several years and provides a marked contrast (taxonomic and preservational) with the fauna of the Melbourne Trough.

LOCALITIES AND AGES

Most of the crinoids described herein come from two main regions (Fig. 1), namely: the Pandanus Creek — Broken River area, 240km northwest of Charters Towers, northern Queensland and the Wellington area, 200km west northwest of Sydney, central New South Wales. Additionally, one species is described from Loyola in the Mansfield district (Fig. 1), 150km northeast of Melbourne, central Victoria, one fragment of a calyx and a weathered specimen are noted from the Burdekin River area just north of Charters Towers (Fig. 1) and two calices are recorded from Mount Etna, 25km north of Rockhampton (Fig. 1). Detailed information on each locality is provided in the Appendix.

PANDANUS CREEK — BROKEN RIVER AREA, NORTH QUEENSLAND

The Broken River Embayment (Broken River Province) to the west of Townsville, is a

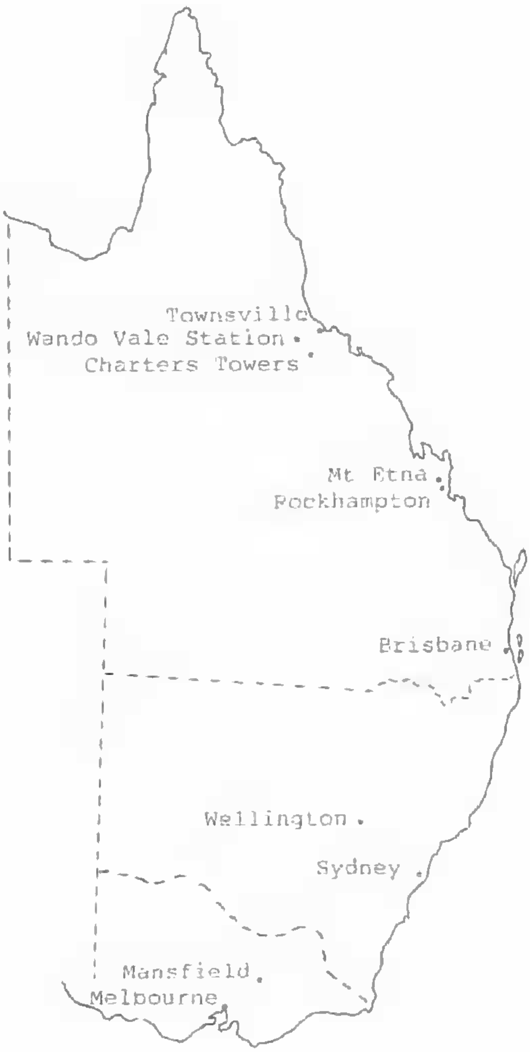


FIG. 1. Sketch map of eastern Australia showing towns referred to in locality descriptions.

deformed sedimentary terrain of the Tasman Fold Belt System faulted against Proterozoic rocks of the Georgetown Inlier to the northwest and lower Palaeozoic rocks of the Ravenswood-Lolworth Block to the south. The southwestern part (Graveyard Creek Subprovince) is less deformed and contains thick siltstone, arenite, conglomerate and limestone deposits (Arnold & Fawckner, 1980; Wyatt & Jell, 1980; Withnall *et al.*, 1988). Biostratigraphy of these carbonates (Jell, 1968; Telford, 1975; Mawson *et al.*, 1985) indicates 3 phases of Devonian marine sedimentation separated in most, if not all, areas by unconformities (Fig. 2). The Graveyard Creek Formation was deposited mainly during the Silurian but Lochkovian carbonates are known at its top; no crinoids are known from this unit. The 250m thick Shield Creek Formation (Wyatt & Jell, 1980), of late Lochkovian to Pragian age, includes the Martins Well Limestone Member that yields many crinoid calices of *Pandanocrinus martinswellensis* gen. et sp. nov. in the vicinity of Martins Well. An associated assemblage of small (less than 1cm) species contains *Parapisocrinus* and *Cupressocrinites*. The third phase of deposition is the Broken River Group (formerly the Broken River Formation), a sequence of mixed facies from terrigenous and nearshore clastics, shallow nearshore shales and muddy carbonates to outer shelf limestones and conglomerates, and possibly slope deposits (Fig. 2). The stratigraphic nomenclature has been revised by Withnall *et al.* (1988) (Fig. 2). Its base is of late Emsian age and its top is Givetian. The group outcrops over wide areas (Mawson *et al.*, 1985, fig. 1) and the full fauna has almost certainly not been sampled. Crinoids are a relatively rare component of muddy carbonate units (Wyatt & Jell, 1980), namely the late Emsian to Givetian Burges Formation and the Givetian Papilio Formation. Most of those described herein come from sites in the vicinity of Storm Dam north of Dosey Outstation (Mawson *et al.*, 1985, fig. 1) north to the Broken River.

BURDEKIN RIVER AREA, NORTH QUEENSLAND

Sediments of the Burdekin Shelf form a sequence of Devonian and Carboniferous age resting unconformably on crystalline basement of the Lolworth-Ravenswood block. The initial Eifelian transgression is represented by the Fanning River Group that includes the basal Big Bend Arkose, and Burdekin Formation of biostromal limestone and calcareous mudstone; it ends with the regressive late Givetian Cultivation Gully Formation. The specimen of *Cupressocrinites abbreviatus* Goldfuss, 1839, found as float in the Burdekin River bed by Zhen Yong Yi, and the indeterminate crinoid found by Greg McNamara in the Hervey Range, were almost certainly derived from the Givetian Burdekin Formation.

MOUNT ETNA, CENTRAL QUEENSLAND

Some 25km north of Rockhampton prominent limestones included in the Mount Holly

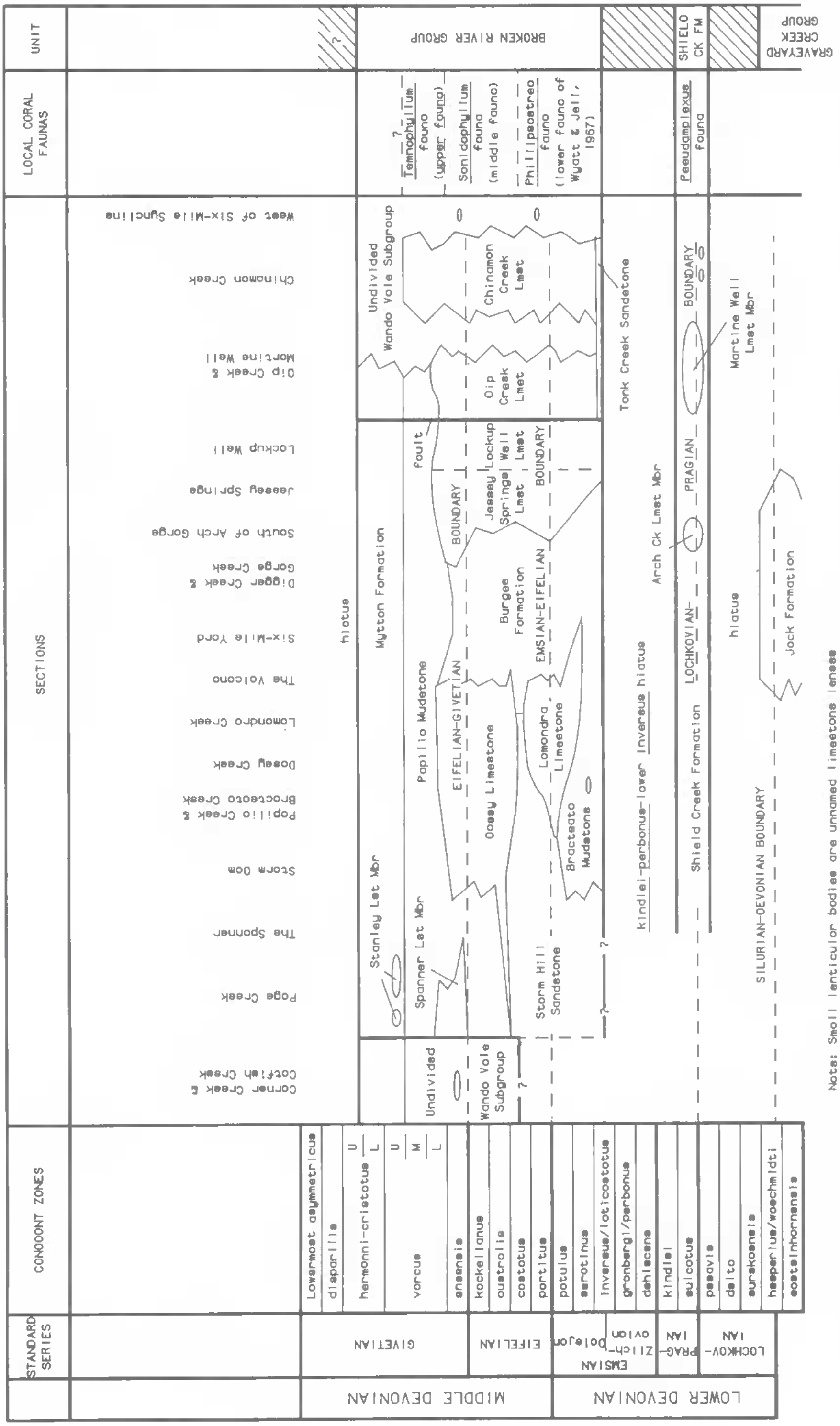


FIG. 2. Early to Middle Devonian units of the Graveyard Creek Subprovince, north Queensland showing their distribution in measured sections (from which conodont faunas have been obtained) against standard conodont zonation.

Beds (Kirkegaard, Shaw & Murray, 1970) are part of the eastern belt of the Craigilee Subprovince. Although the Mount Holly Beds are largely covered by younger post-Carboniferous sediments (Henderson, 1980) muddy limestone on the lower northeastern slopes of Mount Etna have yielded two incomplete calices of *Pandanocrinus*. Correlation and age of the limestone was discussed by Druce (1970), Strusz (1972), and Philip and Pedder (1967). It is now considered to be of early Pragian age, as also is the Martins Well Limestone Member which contains conodonts of the *sulcatus* biozone.

WELLINGTON, CENTRAL N.S.W.

The Molong Geanticline is a structural high extending in a north- south line through central New South Wales (Packham, 1969, fig. 1.1) some 200km west of Sydney. Marine sediments older than Late Devonian occur on both flanks and in the easterly belt limestones and shales, assigned to the Garra Formation, outcrop over a distance of 100km in a band no more than 5km wide (Packham, 1969, fig. 3.16). Crinoidal debris is a relatively common component of this carbonate sequence but calices have been found at only 3 localities. These occurrences are near the town of Guerie at the northern end of the carbonate belt and at two localities in the eastern belt of limestone adjacent to the town of Wellington. The formation, which is over 1000m thick, has been dated as Emsian (Strusz, 1972), Siegenian (Druce, 1970) and Lochkovian to Pragian (Johnson, 1975; Chatterton *et al.*, 1979). We agree with the late Lochkovian to Pragian range.

LOYOLA, CENTRAL VICTORIA

The Melbourne Trough of central Victoria is a structural trough, triangular in shape and containing a thick complete sequence of Early Cambrian to Middle Devonian marine strata overlain by nonmarine sediments. Loyola is a small district some 10–15km southwest of Mansfield that is situated on the extreme eastern edge of the Melbourne Trough. At Loyola a number of small limestone lenses are interbedded in the Norton Gully Sandstone; one of the lenses has been worked since last century in the now abandoned Griffith's Quarry. The fossil fauna of the quarry, principally corals, stromatoporoids and conodonts, has been described in some detail (Chapman, 1925; Hill, 1939; Pedder, 1967; Ripper, 1938. Strusz, 1968; Hill & Jell, 1970; Cooper, 1973). The last mentioned paper dealt with conodonts and provided an early Emsian age as well as a detailed locality map and detailed discussion of the stratigraphy. Mawson (1987, p. 284) reinterpreted the conodonts indicating a Pragian age in the *kindlei* biozone.

FAUNAL AFFINITIES

The most striking features of these crinoid faunas (Fig. 3) from eastern Australia are: 1, the presence of 6 species known previously from western Europe; 2, the presence of *Pandanocrinus* and *Shimantocrinus*, two new genera that we consider are ancestral to the North American Dolatocrinidae as well as *Dolatocrinus* Lyon, 1857 itself; and 3, the predominance of camerate crinoids in these carbonate-dwelling faunules compared to contemporary or slightly older faunas of terrigenous sediments in the Melbourne Trough that include camerates and inadunates in almost even numbers of taxa and individuals (P.A. Jell, unpubl. data).

Five of the seven species identified in relatively large collections from the Papilio Formation in the vicinity of Storm Dam in the *ensensis* and *varcus* conodont zones belong to species that are only known from similarly dated sediments in western Europe (i.e. in the Eifel of Germany or in southwestern England). This is an extremely close match that seems likely to be significant and not a chance occurrence. It accords well with the findings of Campbell & Davoren (1972) in respect of contemporary trilobite faunas at the generic level. For example, they found that compared to 13 Zlichovian faunas from around the world the Australian fauna (mainly from the southeastern part of the continent) had greatest affinity with faunas from Germany and Czechoslovakia. Similarly, Boucot, Johnson & Talent (1969) and Johnson (1979) found the late Emsian — early Eifelian and late Lower Devonian, respectively, brachiopod faunas of Australia were dominated by genera from their Old World Province (i.e. Europe) and they assigned eastern Australia accordingly. Our crinoid data from north Queensland support these views. However, the fauna of the Garra Formation (*sulcatus* biozone) is more equivocal. Of the 6 species recorded, 1 is found in Europe, 1 belongs to a cosmopolitan genus of North America and Europe and 4 are endemic; of these endemics 3 belong to *Pandanocrinus* and *Shimantocrinus*, interpreted

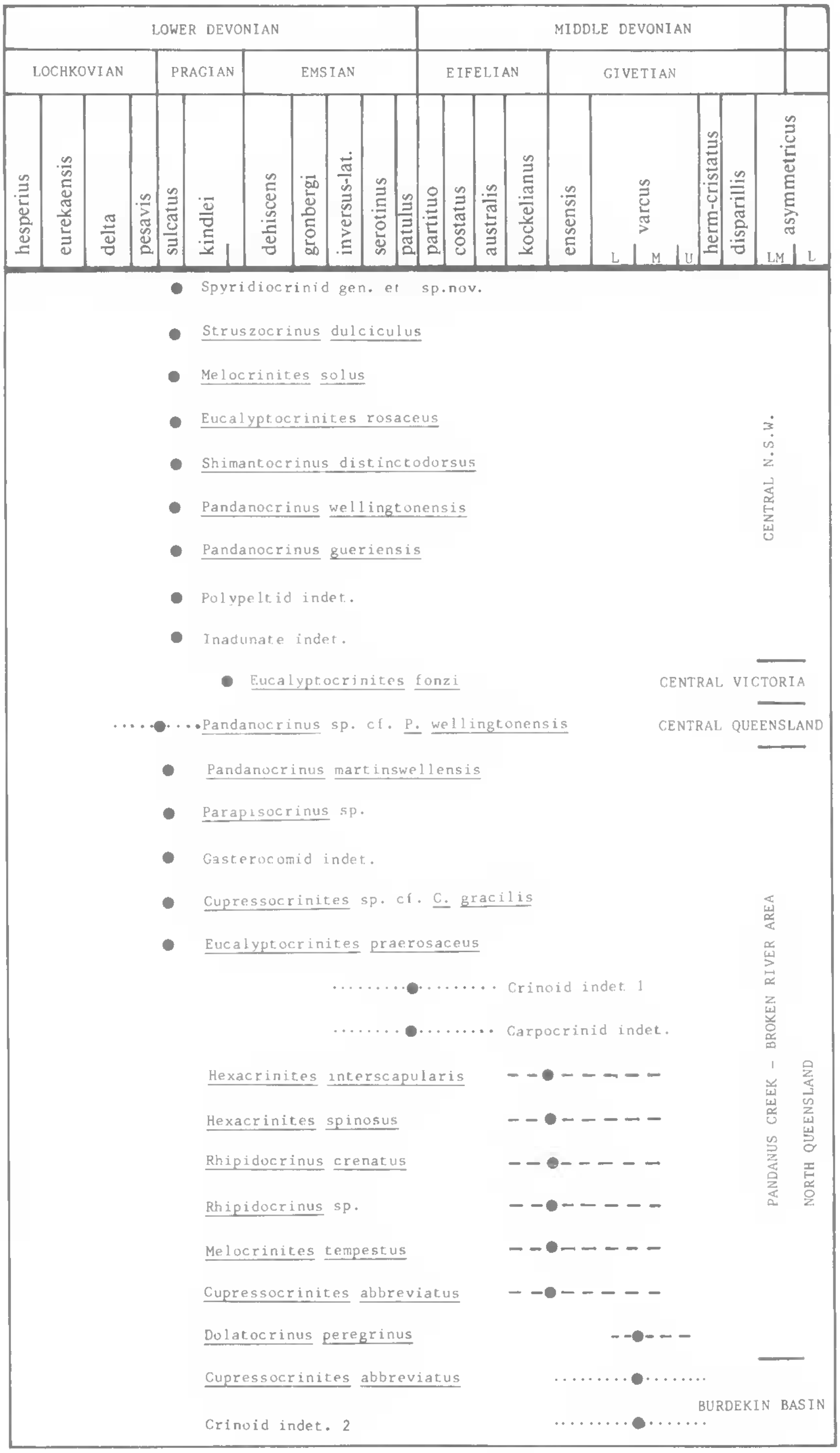


FIG. 3. Range chart for all crinoids described against standard conodont zonation. Dashed lines indicate known ranges; dotted lines indicate uncertain ranges.

below as ancestral to the largely North American Dolatocrinidae that is also represented in the Givetian of north Queensland by *Dolatocrinus*. Affinities of this fauna remain unclear but it is suggested that migration to North America was possible during the Emsian. Overall affinities of these eastern Australian crinoid faunas seems to be more strongly with the European Old World Province.

Detailed analysis of the content of these carbonate faunas as opposed to terrigenous faunas of Victoria where inadunates form a

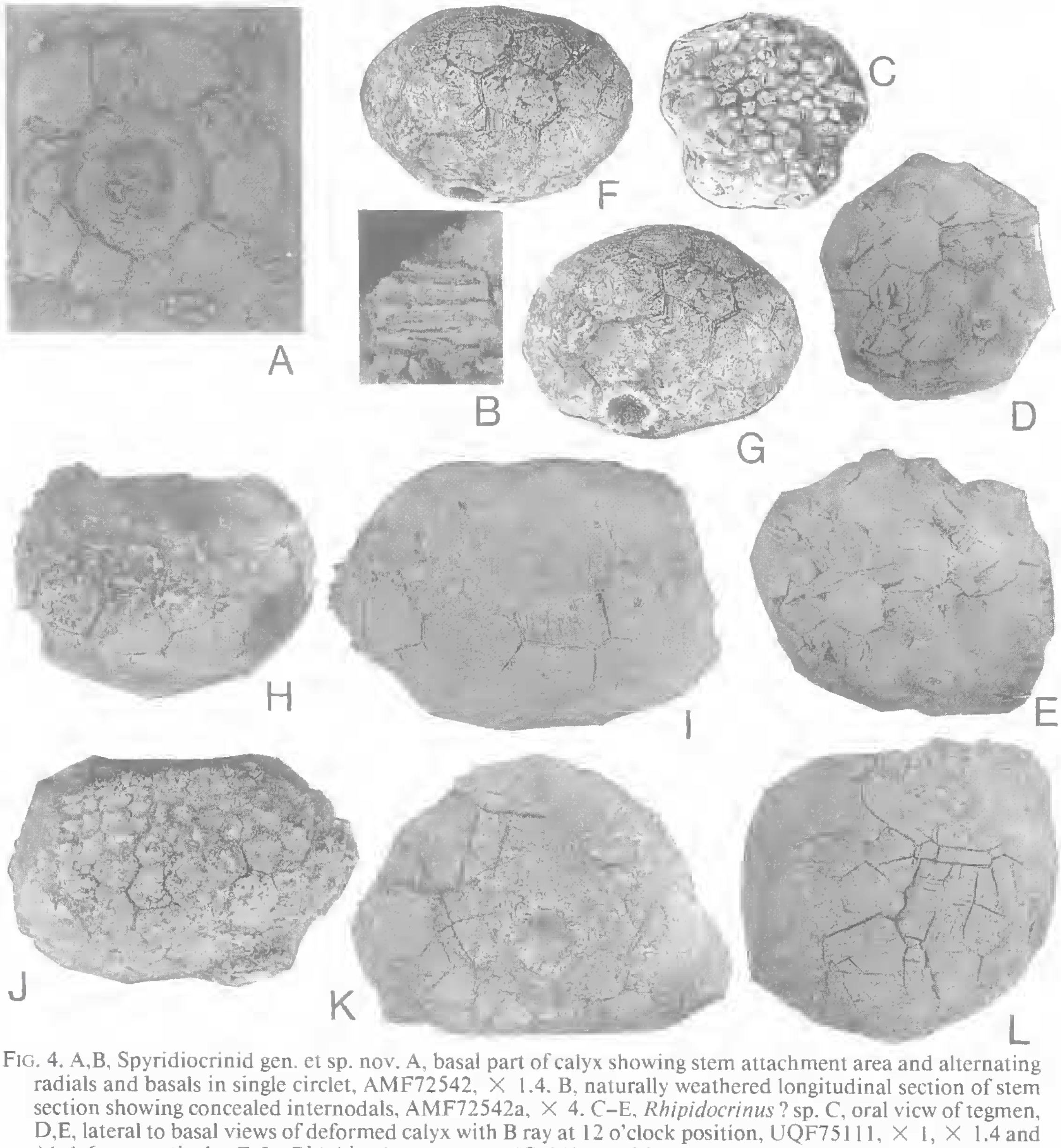


FIG. 4. A,B, Spyridiocrinid gen. et sp. nov. A, basal part of calyx showing stem attachment area and alternating radials and basals in single circlet, AMF72542, × 1.4. B, naturally weathered longitudinal section of stem section showing concealed internodals, AMF72542a, × 4. C–E, *Rhipidocrinus* ? sp. C, oral view of tegmen, D,E, lateral to basal views of deformed calyx with B ray at 12 o'clock position, UQF75111, × 1, × 1.4 and × 1.6, respectively. F–L, *Rhipidocrinus crenatus* (Goldfuss, 1831). F,G, lateral views of calical fragment (orientation not known), UQF75112, × 1. H–J, lateral views of most complete calyx available from Australia, UQF75113, H, with C ray just left of centre × 1, I, with B ray central and C ray at left × 1.2, J, with D ray to right of centre and E ray to left × 1. K, basal view of fragmentary cup with C ray at 10 o'clock position QMF14771, × 0.9. L, lateral view of incomplete calyx (orientation unknown), QMF14869, × 0.8.

significant proportion of the whole fauna must await results of study of the latter faunas now in progress. However, it would seem that this significant ecological distinction may be identified as a determining factor in the distribution of inadunate crinoids and should be looked for in other areas of the world. It might be speculated that the carbonate environments had for one reason or another caused the non-camerate skeleton to disaggregate whereas the camerates were more securely held together. If this proves to be the real reason for the disparity mentioned above then crinoidal debris in these formations will prove to belong mainly to non-camerates; that study is beyond the scope of this paper.

SYSTEMATIC PALAEONTOLOGY

Terminology used herein as far as possible follows that used in the *Treatise on Invertebrate Paleontology Part T*. Material is deposited in the palaeontological collections of the following institutions, hereinafter indicated by the prefix shown : Department of Geology, University of Queensland, Brisbane (UQF), Queensland Museum, Brisbane (QMF), Australian Museum, Sydney (AMF), James Cook University, Townsville (JCF) and Museum of Victoria (NMVP). Locality Registers in these institutions are indicated by the prefixes: UQL — Department of Geology, University of Queensland, QML — Queensland Museum, NMVPL — Museum of Victoria.

Class Crinoidea
Subclass Camerata
Order Diplobathrida
Family Spyridiocrinidae Jaekel, 1918

Spyridiocrinid gen. et sp nov.
(Figs 4A,B, 5)

MATERIAL EXAMINED
AMF72542, a weathered calical base from QML512.

OCCURRENCE
Pragin (*sulcatus* biozone), Garra Formation, near Wellington, central New South Wales.

DESCRIPTION
Calical fragment approximately 20mm in diameter, flat, exhibiting only the infrabasal circlet; next circlet of 10 plates consisting of basals alternating with radials. A prominent, broadly pitted ornament evident on unweathered parts of a few plates. Infrabasal circlet 10-sided, approximately 10mm across and almost completely concealed by the stem attachment. Small part of each infrabasal evident along the base of the radial plates outside the stem attachment area indicating 5 infrabasals. Stem circular, of low nudinodals concealing very short internodals; columnals with well-developed crenularia but not reaching periphery; pentalobate axial canal evident. Next circlet of 10 plates in two sets of 5, with each set having a distinctive shape. One set, probably the basals, consisting of rectangular plates only a little higher (5mm) than wide (4mm), but slightly lower than the other set. Second set, probably the radials, consisting of equidimensional (6mm high and 6mm wide) hexagonal plates, with widest point near top of plate at height of top of basals, with two short oblique sides converging up from widest point to top of plate. Remainder of crown unknown.

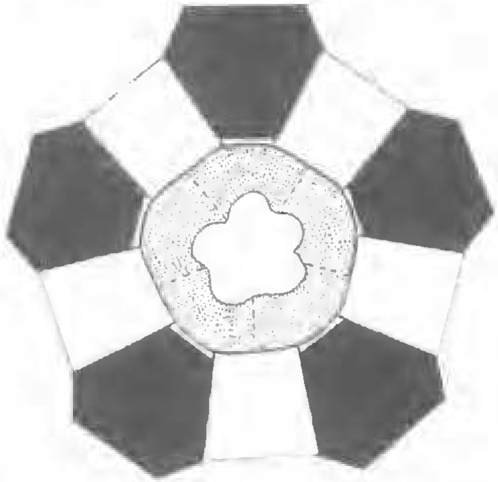


FIG. 5. Spyridiocrinid gen. et sp. nov. plate diagram with inferred sutures between infrabasals dashed but not observed.

REMARKS
This calical fragment could be readily assigned to the Zygodiplobathrina of Ubaghs (1953, 1978) based on the circlet of 10 plates in 2 distinct sets surrounding the stem attachment which conceals the infrabasal circlet. However, Brower (1975) and Haugh (1979, p. 11) have considered this taxon to be polyphyletic. Accordingly we have sought possible relatives from among those genera that possess zygodiplobathrid bases. The flat

calical base and structure of the stem strongly suggest the Spyridiocrinidae. The distinctly different shapes of the radials and the basals is indicative of a new genus because all described species of *Spyridiocrinus* Oehlert, 1889 possess basals and radials of uniform shape and size. However, with this one incomplete calyx, further characterization of the genus is impossible. Breimer (1960, p. 257, reproduced Ubaghs, 1978, fig. 239.1f) showed a juvenile specimen of *Rhipidocrinus crenatus* Goldfuss, 1831 with basals and radials alternating in a single circlet around the infrabasals. However, the N.S.W. specimen is distinguished by its size, wider base of radials contacting infrabasals, different ornament on plates, and possibly stem structure.

Detailed structure of the stem is derived from a weathered stem fragment adjacent to the specimen and interpreted as being part of this individual as are many other small calical and arm plates in the immediate vicinity.

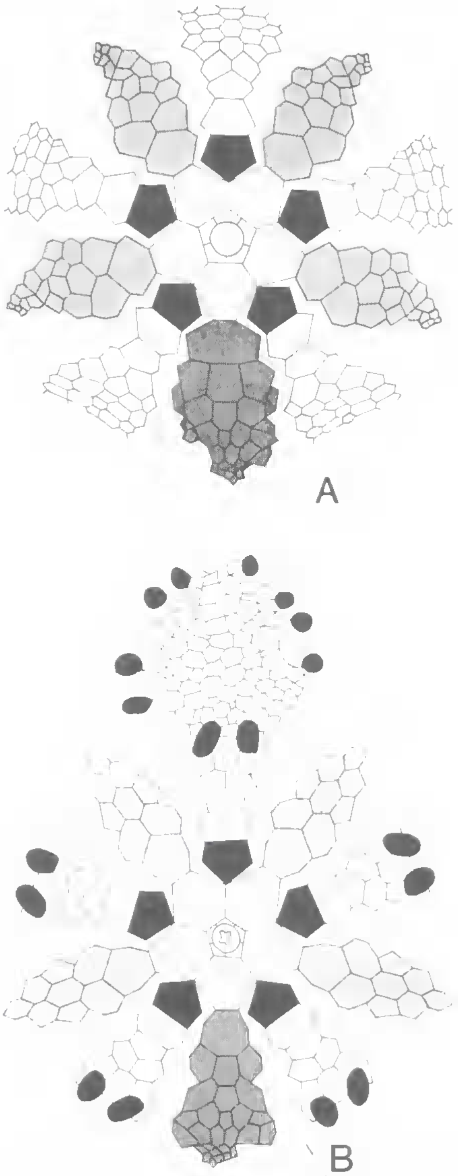


FIG. 6. Plate diagrams of A, *Rhipidocrinus crenatus* (Goldfuss, 1831) and B, *Rhipidocrinus*? sp. including the tegmen.

Superfamily Rhodocrinitoidea
Family Rhodocrinitidae Roemer, 1855

Rhipidocrinus Beyrich in Zittel, 1879

TYPE SPECIES

Rhodocrinites crenatus Goldfuss, 1831 from the Givetian of West Germany; by original designation.

DISCUSSION

This genus was discussed in detail by Breimer (1960). Unfortunately features considered by him to be distinctive of the genus (i.e. the style of branching and variation in the arrangement of lower calical plates) are not available on the Australian specimens. Nevertheless, German specimens of the type species (see Remarks on the species below) are very similar in all points where comparisons can be made.

Rhipidocrinus crenatus (Goldfuss, 1831)
(Figs 4F–L, 6A)

MATERIAL EXAMINED

Holotype Goldfuss, 1831, pl. 64, fig. 3.

Queensland material assigned. UQF75112, an incomplete calyx without free arms, stem or tegmen from UQL5229; UQF75113, a weathered fragment of a calyx from UQL5318; QMF14771, a badly weathered calyx showing basal plating from UQL5320; QMF14869, a damaged and weathered calyx showing plating of upper part of calyx and free arm bases from UQL5321.

OCCURRENCE

Late Eifelian — Givetian, Papilio Formation, near Storm Dam, Wando Vale Station, north Queensland.

Description

UQF75113. This specimen shows only one ray of the calyx and the adjacent interbrachials up to the level of the first secundibrachs. All the plates are weathered so as to be virtually smooth but some remnants of the radial ornament are evident in a few places. In this weathered state the plates are approximately 1mm thick. The pentagonal infrabasal circlet has a broad round depression for stem attachment. Hexagonal basals 10mm wide and 9mm high have their greatest width 2mm from their bases. The radial is pentagonal, 11mm wide and 10mm high with greatest width 4.5mm from bottom. The first primibrach is hexagonal, 12mm wide and 7mm high. The second primibrach is pentagonal, axillary, 8.5mm wide and 6.5mm high. Interbrachials begin with a large (12mm wide by 10.5mm high), 7-sided plate contacting the basal, radial and first primibrach, and supporting two smaller plates above.

UQF75112. This specimen has been slightly crushed laterally (i.e. through the A ray — CD interray axis); plate displacement and overriding has occurred in the basal region, where weathering has been most pronounced, smoothing off the ornament. The entire outline is not available for any one basal. Radials are variable in shape, 6-sided where observable. First primibrach 6-sided but rather irregular in shape in most rays. Second primibrach axillary, 6-sided in D and E rays but 5-sided in B and C rays (not evident in A ray). First secundibrach axillary, 6-sided, almost as large as second primibrach. First tertibrach supporting a fixed ramule on outer side of ray. Plates of fixed ramule marginally narrower and generally higher than main arm plates. At least 5 tertibrachs, usually hexagonal, fixed in calyx. Interprimibrachs numerous, up to 20 per interray: lowest one being largest plate in calyx, 7-sided, resting directly on basal and supporting two plates above; interprimibrachs irregularly arranged. Intersecundibrachs in single column of at least 4 plates. Primanal octagonal, supporting 3 plates above; remainder of anal series not clearly evident. Ornament, where present, of strong central boss with strong radial ridges on larger plates with radial ridges less prominent on smaller plates. Medial ray ridge evident in C ray and dividing on second primibrach.

QMF14771. This large individual was approximately 50–60mm in diameter but most of it is weathered away. The five equal infrabasals are evident forming a raised pentagonal base with wide axial canal. Numerous small pits in the infrabasals were probably caused by weathering rather than by boring organisms. The five large basals and several radials are evident with one ray exhibiting the typical structure upto the second secundibrach.

QMF14869. This badly damaged individual exhibits some of the ornament normal to sutural margins although weathered considerably. It also gives an idea of calical shape although it is laterally compressed and shows several of the free arm bases at the upper rim.

Upper arms, stem and tegmen not available.

Remarks

This assignment to *R. crenatus* depends on comparison with specimens assigned to that species by Schultze (1867, pl. 7, fig. 1,1a– n) as well as reference to the original material of Goldfuss (1831, p. 211, pl. 64, fig. 3). In particular Schultze (1867, pl. 7, fig. 1g) showed a calyx with plates ornamented in exactly the same way as those of the Australian specimen (UQF75112), with the same arrangement of plates in the brachial series and particularly in the fixed ramules arising from the second secundibrach. The column of relatively large intersecundibrachs is also similar. Schultze (1867) illustrated a considerable variation in the calices he assigned to this species, recognizing two varieties. Although these may well represent separate species we have not examined Schultze's or any other European material and so prefer to assign the Australian form to *R. crenatus* in its broader sense. Breimer (1960) revised *R. perloricatus* Schmidt, 1905, elucidating many generic features in the process and distinguishing it from *R. crenatus* by its smooth, globose, calical plates.

Rhipidocrinus ? sp.
(Figs 4C–E, 6B)

Material Examined

UQF75111, a calyx, damaged in some plates and also distorted by crushing from UQL5272.

Occurrence

Early Givetian, Papilio Formation, near Storm Dam, Wando Vale Station north Queensland.

Description

Calyx bowl-shaped, of moderate height, with subhorizontal base, approximately 25mm in diameter and 15mm high, with smooth unornamented gently convex plates. Infrabasal circlet pentagonal, individual plates not discernible, apparently fused; circular stem attachment area situated centrally occupying most of infrabasal circlet, with central pentalobate canal evident in section. Basals large, 6mm high and 6mm wide at widest point, hexagonal except in C–D interray where it is 7-sided, in contact laterally with other basals for half height. Radials pentagonal except in C ray where it is hexagonal, isolated from other radials. First primibrach hexagonal, wider (6mm) than high (4mm). Second primibrach axillary, pentagonal, smaller than lower plates (4mm wide 4mm high at greatest height). First secundibrach usually hexagonal but a little variable in shape. Second secundibrach a large plate almost enclosing the base of the free arm. Ten free arms, no details available. Intersecundibrachs 2 only, lower one hexagonal, second between bases of five arms, Interprimibrachs numerous; lowest one hexagonal, large, 6.5mm wide by 6mm high, resting directly on basal with horizontal suture, and supporting 2 plates in second row then 3, 2 and 1 in succeeding rows. C–D interray with two pentagonal primanals separated by a vertical suture, with succeeding rows of 3, 3 and 2 up to the large anal opening. Tegmen of small polygonal plates, rather flat, with large anal opening slightly elevated near margin in posterior interray. Free arms and stem not known.

Remarks

This specimen comes from the same unit as those described above as *R. crenatus* and one is tempted to infer that it may be a juvenile of that species. However, the smooth plates, the ten free arms emanating from the second secundibrachs, lack of fixed ramule and two primanals resting on a basal in C–D interray, all mitigate against such an identification. Nevertheless Breimer (1960, p. 257, fig. 5, righthand illustration; reproduced by Ubaghs, 1978, fig. 239, 1d) showed a juvenile of *R. crenatus* with two primanals resting on a single basal in the C–D interray. It should also be noted that the holotype of *R. crenatus* does not display elaborate ornament nor does it incorporate large numbers of secondary and higher brachials into the calyx; it is highly likely that this specimen is a juvenile of *R. crenatus*.

Class Camerata
Order Monobathrida
Suborder Tanaocrinina
Family Carpocrinidae deKoninck & Le Hon, 1854

Carpocrinid indet.
(Figs 7G–J,8)

Material Examined

QMF14881, a badly damaged calyx from QML547 (=UQL5209).

Occurrence

Late Emsian — early Eifelian, Burges Formation just west of the Broken River Gorge, Wando Vale Station, north Queensland, collected by Aye Ko Aung.

Description

Calyx 20mm in diameter, with vertical sides and weakly convex base. Basal circlet hexagonal, of three equal plates, with sutures between them in B and E rays and C–D interray; axial canal small and weakly pentalobate. Radial circlet of six (five radials and primanal) large hexagonal plates each one wider than high. First primibrach quadrate, variable in shape from transverse to square or higher than wide, with gently convex edges. Second primibrach axillary, low, pentagonal. Single secundibrach axillary, often irregularly shaped particularly on upper side. Fixed tertibrachs irregularly shaped, markedly smaller than secundibrach and tending to alternate in zigzag fashion. Four arms per ray, the two outer arms apparently with smaller bases than the inner ones. Single intersecundibrachs and intertertibrachs present. Free arms unknown. Interprimibrachs restricted to one large 9-sided plate as wide as high, resting on the radial circlet and isolated from the tegmen. C–D interray with primanal in radial circlet supporting three secundanals with central one being markedly larger than laterals, isolated from tegmen or possibly connected by thin high plate. Tegmen high, possibly drawn out into tall vertical extension (anal tube?), consisting of large irregularly arranged polygonal plates.

Remarks

Following the classification of Ubaghs (1978) this species is a monocyclic camerate with hexagonal basal circlet of three equal plates, with radials adjoining each other except for posterior primanal in same circlet, with quad-

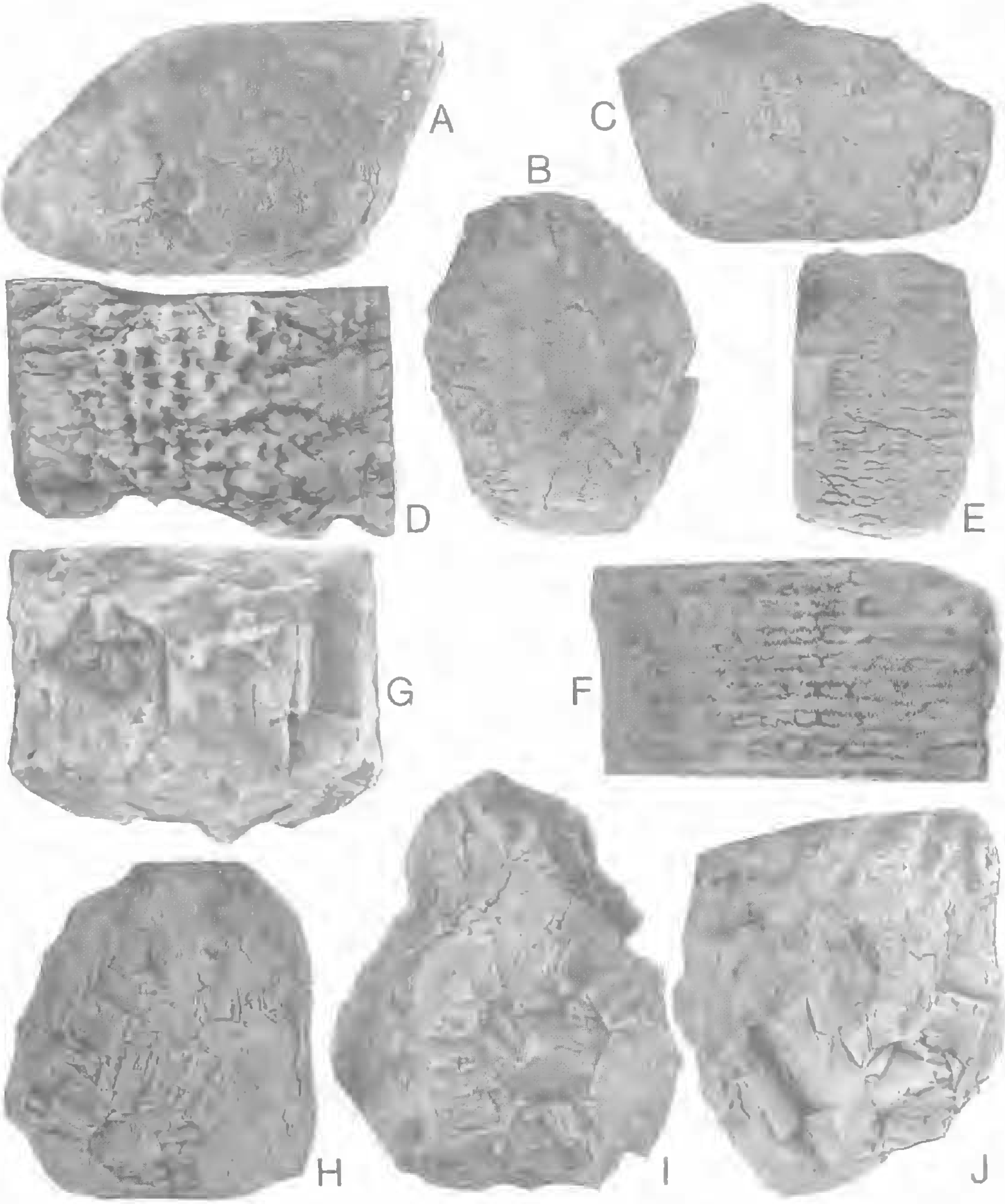


FIG. 7. A–F, Crinoid indet. 1. A–C, large calyx with few plates evident in two lateral and basal views (orientation uncertain), repectively, QMF14951. × 0.8. D–F, stem fragments in lateral view and variously weathered in D and F. QMF14954, 14952 and 14953, respectively, × 2. G–J, Carpocrinid indet. QMF14881, × 2. G, lateral view in C ray showing quadrate first primibrach and axillary second primibrach as well as almost vertical sides of calyx. H, lateral view in C–D interray showing hexagonal primanal in radial circlet supporting 3 secundanals whose margins are defined only by the margins of the single crystal structure of each plate. I, basal view with hexagonal basal circlet of 3 plates surrounded by radial circlet of 6 plates. J, lateral view in B ray showing some of smaller fixed brachials tending to biserial arrangement and possible development of 4 arms per ray.

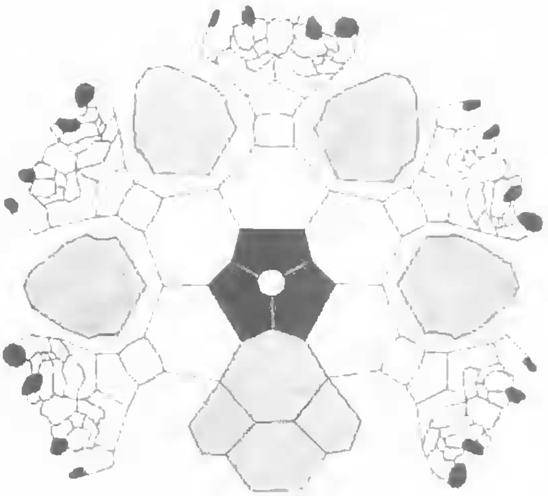


FIG. 8. Plate diagram of Carpocrinid indet.

rate first primibrach and 3 secundanals. This combination places it in the Carpocrinoidea. Within this superfamily this extremely poorly preserved specimen resembles most closely the Silurian *Desmidocrinus* of the Carpocrinidae; the single large interprimibrach, quadrate primibrach, 4 arms per ray, 2 fixed secundibrachs and fixed tertibrachs being significant. However, it is not assigned generically because of the poor understanding available from this specimen. It may be distinguished from *D. laurelianus* Springer, 1926 and *D. dubius* Springer, 1926 by its flatter bases, by its less transverse first primibrach and by its prominent single interprimibrach per interray. These two species from the Silurian Laurel Limestone at St Paul, Indiana, are the closest known forms to this Australian species but their separation in time and space suggests that they possibly represent different genera.

Struszocrinus gen. nov.

ETYMOLOGY

For Dr Des Strusz, Bureau of Mineral Resources, Canberra, for his extensive contribution to the stratigraphy and coral faunas of the Wellington District.

TYPE SPECIES

Struszocrinus dulciculus sp. nov. from the Garra Formation, Pragian, near Wellington, central New South Wales.

DIAGNOSIS

Carpocrinid with high bowl-shaped calyx; quadrate (rarely 5- or 6-sided) first primibrach; 4 to 7 ungrouped arms per ray; one secundibrach and, if present, one tertibrach per arm fixed in calyx; interprimibrachs 1 to 4 per interray not depressed and with a large 8-sided plate at the base resting on the radials; 2 or more usually 3 secundanals; 5 or 7 anal plates having a central anal column; tegmen of relatively few large plates; strong anal tube at least one third height of calyx.

DISCUSSION

The 2 major lineages of the Tanaocrinina that existed through the Devonian are the Periechocrinoidea and the Carpocrinoidea of Ubaghs (1978); the latter was referred to as the 'desmidocrinid section' by Moore & Laudon (1943, p. 86). The distinction between these two lineages is not always clear but Moore & Laudon (1943) explained the principal point as the early development of the quadrate first primibrach in the Carpocrinoidea. Ubaghs (1978, p. T443) noted in his diagnosis of the Periechocrinoidea that advanced members may have quadrangular first primibrachs. Ausich (1987) discussed the problems associated with distinction of these two superfamilies defining the Carpocrinoidea as a specialized lineage with reduced number of plates in the cups. As *Struszocrinus* has 4-, 5- and 6-sided first primibrachs this feature is not altogether definitive although the two latter forms are uncommon. Considering the normal form of this plate to be quadrate, because that is the shape it most commonly assumes with the extra sides as remnants from when interprimibrachs were smaller and more numerous, this Early Devonian form is assigned to the Carpocrinoidea. The free arm bases forming a distinct circlet just below the tegmen and anal tube suggest placement in the Batocrinidae but that family, first appearing and common in the Early Carboniferous contains no record of reduction in the number of secundanals, even in aberrant specimens. The single specimen of *S. dulciculus* with 2 secundanals may be considered aberrant. However, if this reduction has any significance then consideration must be given to the Periechocrinoidea where the Actinocrinitidae is a family that evolved apparently near the base of the Carboniferous with 2 secundanals in all its members. Moreover, Breimer (1962, p. 40) described an aberrant specimen of *Pyxidocrinus collensis* Breimer, 1962 (Periechocrinidae) with 2 secundanals in a species which otherwise always has three. The close similarity between *S. dulciculus* and the actinocrinitid *Cactocrinus proboscidialis* (Hall, 1858) particularly in having 4- and 6-sided first primibrachs in the same specimen (Ubaghs, 1978, fig. 266, 1b) must be noted. However, radiation of that family has been inferred from a common ancestry in the Early Carboniferous, probably through the Periechocrinidae and Eumorphocrininae Ubaghs, 1978 (Brower, 1967). Early Devonian *Struszocrinus* must therefore be considered a homeomorph of the highly evolved Carboniferous actinocrinitid *Cactocrinus*. Among Early Devonian periechocrinitids the combination of ungrouped arms, anal tube, large tegminal plates and quadrate first primibrachs is unknown and affinities must be denied.

This confusing combination of features makes our assignment uncertain until more of its close relatives are known. At present we consider *Struszocrinus* to be an advanced member of the Carpocrinidae. In its rare 5- and 6-sided but commonly 4-sided first primibrachs it presents the same sort of variation described by Ausich (1987) in his Llandoverian periechocrinids but the most usual quadrate shape suggests the Carpocrinoidea. Other features are consistent with this assignment as far as the family is known. *Struszocrinus* may well be ancestral to some if not all the Batocrinidae but that contention will depend on finding the members of such a lineage in the Middle and Late Devonian.

Struszocrinus dulciculus sp. nov.
(Figs 9, 10)

Etymology

From the Latin diminutive of *dulcis* — sweet; the first specimen seen by the senior author was described by its collector as a 'little sweetie'.

Material Examined

Holotype AMF72522, paratypes AMF72521, 72523 to 72528 and QMF14534 to 14535 all from QML512.

Occurrence

Pragian (assumed *sulcatus* biozone), Garra Formation, near Wellington, central New South Wales.

Diagnosis

As for genus.

Description

Calyx high, bowl-shaped with almost parallel sides just below the free arm bases and subhorizontal base; upto 20mm high excluding anal tube. Basal circlet barely visible in lateral view, of 3 equal plates separated by sutures in the B and E rays and the C–D interray, with small circular axial canal. Radial circlet of 3 hexagonal radials in A, C and D rays, two 7-sided radials in B and E rays and a 7-sided primanal; plates of this circlet largest in calyx, wider than high, all with horizontal upper surfaces; first primibrachs usually quadrate but in some individuals 5- or even 6-sided (Fig. 9A,J) in the A ray or the C and D rays (no pattern apparent), with convex margins, of variable height to width ratio but usually wider than high. Second primibrach axillary, wider than high, usually 5-sided but 6-sided or rarely 7-sided when in contact with upper interprimibrachs in any ray. Secundibrachs fixed, usually 1 rarely 2 in each half ray, axillary, usually 6-sided and wider than high. Tertibrachs usually only one or two fixed in calyx, first one often axillary (particularly inner one of each half ray); becoming wedge-shaped distally, apparently leading to biserial arms. Inter-
secundibrachs not present. Interprimibrachs usually 2 or 3 per interray, rarely 4 or 5, one large plate at base with 8 or 9 sides followed above by one or more tiny plates; interprimibrachs isolated from tegmen by spread of fixed portions of arms. Large primanal higher than wide in radial circlet, but narrower than any radial; 3 secundanals in most specimens but only 2 in one specimen (Fig. 9D); a further row of 3 plates, the central one of which has high tapering central spire connecting with tegmen between arm bases; central column of anals tall and distinctive; total number of anal plates usually 5–7. Tegmen of large polygonal plates of gentle convexity almost half as high (excluding anal tube) as rest of calyx; five large orals medially, with C–D oral commonly strongly projecting; anal tube high but full extent unknown, situated subcentrally just posteriorly. Arm bases forming continuous circle around calyx interrupted only in C–D interray. Free arms and stem unknown.

Remarks

Intraspecific variation is noted above in respect of shape of first primibrach and number of secundanals, and other variables include number of arms per ray, shape of secundibrachs,

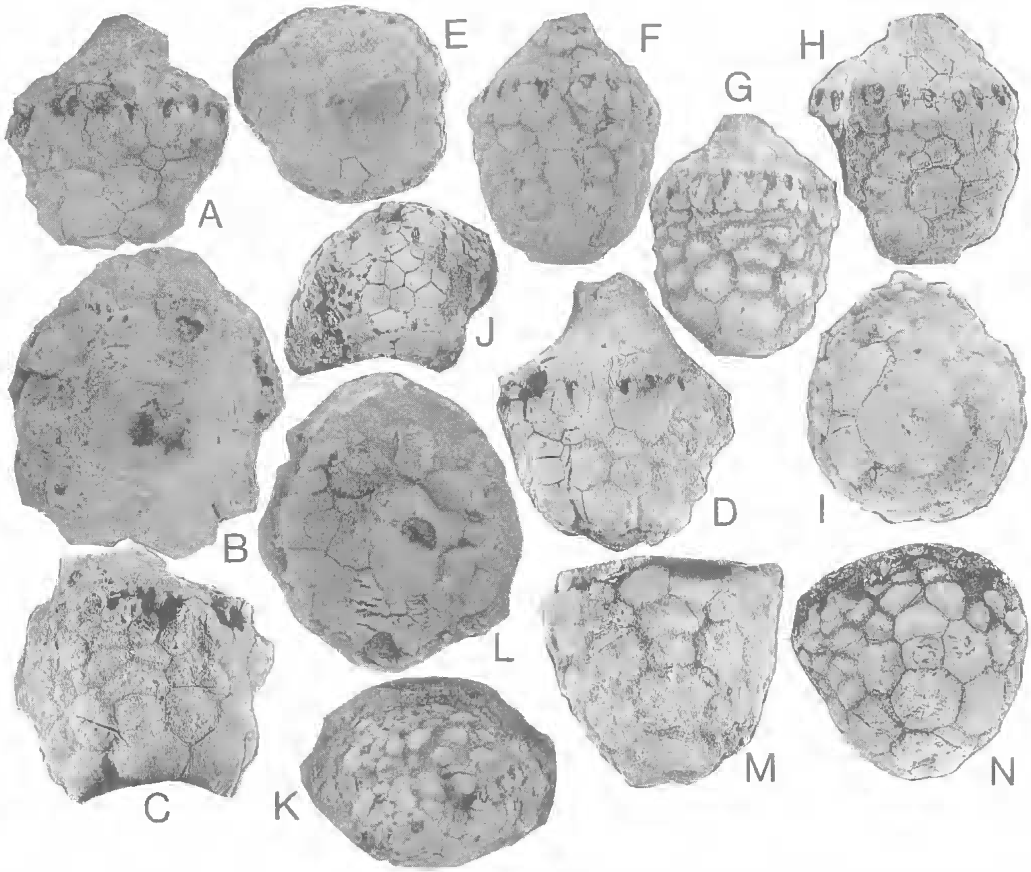


FIG. 9. *Struszocrinus dulciculus* gen. et sp. nov. all from QML512. A–D, AMF72522, × 1.5, × 2, × 1.8 and × 1.5 respectively. A, lateral view of A and E rays. B, tegmen showing fractured anal tube (A ray is at 12 o'clock). C, lateral view of B ray. D, lateral view of C–D interray showing hexagonal primibrach in radial circlet supporting 2 secundanals. E–I, Holotype, AMF72521, E and I × 2, F–H × 1.5. E, tegmen with A ray at 9 o'clock position. F, lateral view of C–D interray showing 3 secundanals resting on 7-sided primanal. G,H, lateral views of A ray and D–E interray respectively. I, basal view with A ray at 12 o'clock showing 3 equal basals and radial circlet of 6 plates. J,K, lateral and tegminal views of deformed calyx with D ray just right of centre and showing strongly convex plates of tegmen, AMF72526, × 2. L, small incomplete calyx in tegminal view with A ray at 12 o'clock, showing large tegminal plates, AMF72525, × 2.5. M, lateral view of incomplete calyx (orientation uncertain), AMF72527, × 2. N, lateral view of incomplete calyx in D ray showing an hexagonal second primibrach, QMF14543, × 1.5.

composition of tegmen, and general calical shape.

Superfamily Hexacrinitoidea
Family Hexacrinitidae Wachsmuth & Springer, 1885

Hexacrinites Austin & Austin, 1843

TYPE SPECIES

Platycrinus interscapularis Phillips, 1841 from the Middle Devonian of southern England.

Hexacrinites interscapularis Phillips, 1841
(Figs 11, 12G–M)

MATERIAL EXAMINED

Holotype Philips, 1841, pl. 14, fig. 39. Queensland Material UQF75119 from UQL4442; UQF75120–75123 from UQL4427; UQF75124 from UQL5228, UQF75125 from UQL5267; UQF75126 and 75127 from UQL5234; UQF75128 from UQL5317; UQF75129, 75130 and 75135–75138 from UQL5360; UQF75131, 75132 and QMF14597 from UQL5318; UQF75133 from UQL5227, UQF75134

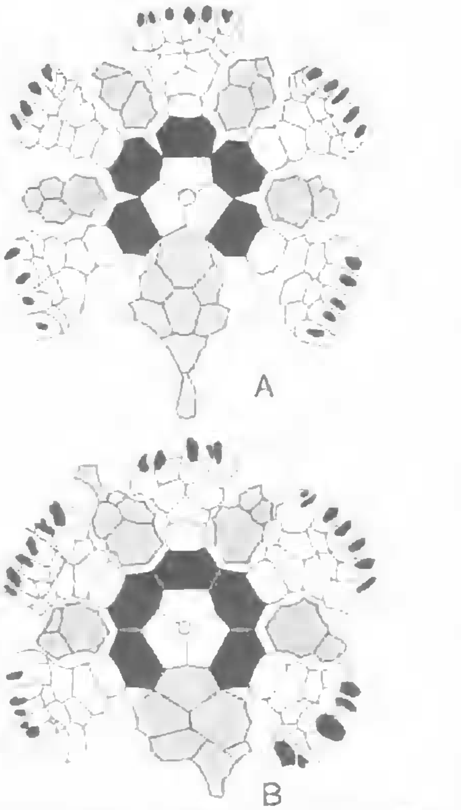


FIG. 10. Plate diagram of *Struszocrinus dulciculus* gen. et sp. nov. A from AMF72521 and B from AMF72522.

from UQL4745; QMF14580 from UQL5305; QMF14594 and 14595 from UQL5252; QMF14596, 14600, 14602 from UQL5356; QMF14604 from UQL5335; QMF14743, 14745,14834, 14871, 14874 from UQL5321; QMF14755, 14756, 14763 from UQL5320; QMF14843, 14845 from UQL5218; QMF14849 from UQL5267.

OCCURRENCE

Late Eifelian and Givetian, Papilio Formation, near Storm Dam, on Wando Vale Station, north Queensland.

DESCRIPTION

Calyx high bowl-shaped with a subhorizontal base and slender stem judging from diameter of attachment area on base of calyx. Stem attachment a concave circular area with distinct outer rim and pierced centrally by extremely fine axial canal (Fig.12H) but on slightly weathered specimens this axial canal becomes distinctly triangular (Fig.12G). Hexagonal basal circlet divided into three large equal plates by sutures in the B and E rays and C–D interray. Large radial plates standing almost vertically and becoming slightly wider upwards; upper margin with relatively wide lateral sections ascending medially, then narrow horizontal sections either side of the arm insertion. Arms not known except for first three fixed brachials; first primibrach usually low and narrow not in contact with interbrachials at all, but in largest specimen (Fig.12L) as high as second primibrach and extending laterally to butt against first row of interbrachials; second primibrach axillary, usually higher than first and extending laterally to first level of interbrachials; discrete, slender axial canal penetrates the brachials and can be seen to divide into the secundibrachs. Primanal approximately same size as radials, hexagonal supporting a pentagonal and an hexagonal plate above and both are isolated from the arms by high narrow plates resting on the C and D radials. Interprimibrachs three in number with hexagonal central one narrowing upwards and lateral ones slightly excavated where they margin the arm The tegmen is about half as high as rest of calyx and is composed of relatively large polygonal plates with some differentiation into smaller plates in the five radial areas. Anal opening on a distinct but low protrusion just posterior to the centre of tegmen. Ornament on all the calical plates of coarse tubercles which become more numerous but less prominent with growth.

DISCUSSION

This species has previously been described from England and Germany. The Queensland material is almost identical and we consider the minor differences outlined below to be intraspecific variation. The specimen illustrated by Schultze (1867, pl. 8, fig. 5) from Kerpen, Germany has its fourth primibrach axillary, has a more convex base, more prominent ornament and relatively larger tegminal plates. The English material has a more convex base. These differenees could not be considered of specific significance.

One large specimen (Fig. 12I,J) exhibits an extra plate of irregular outline and position on the lower corner of the A radial. This plate is 5-sided with a pointed margin embayed into the adjacent basal, with a broad groove running vertically across one side of it and the two vertical sides are not parallel. This plate can only

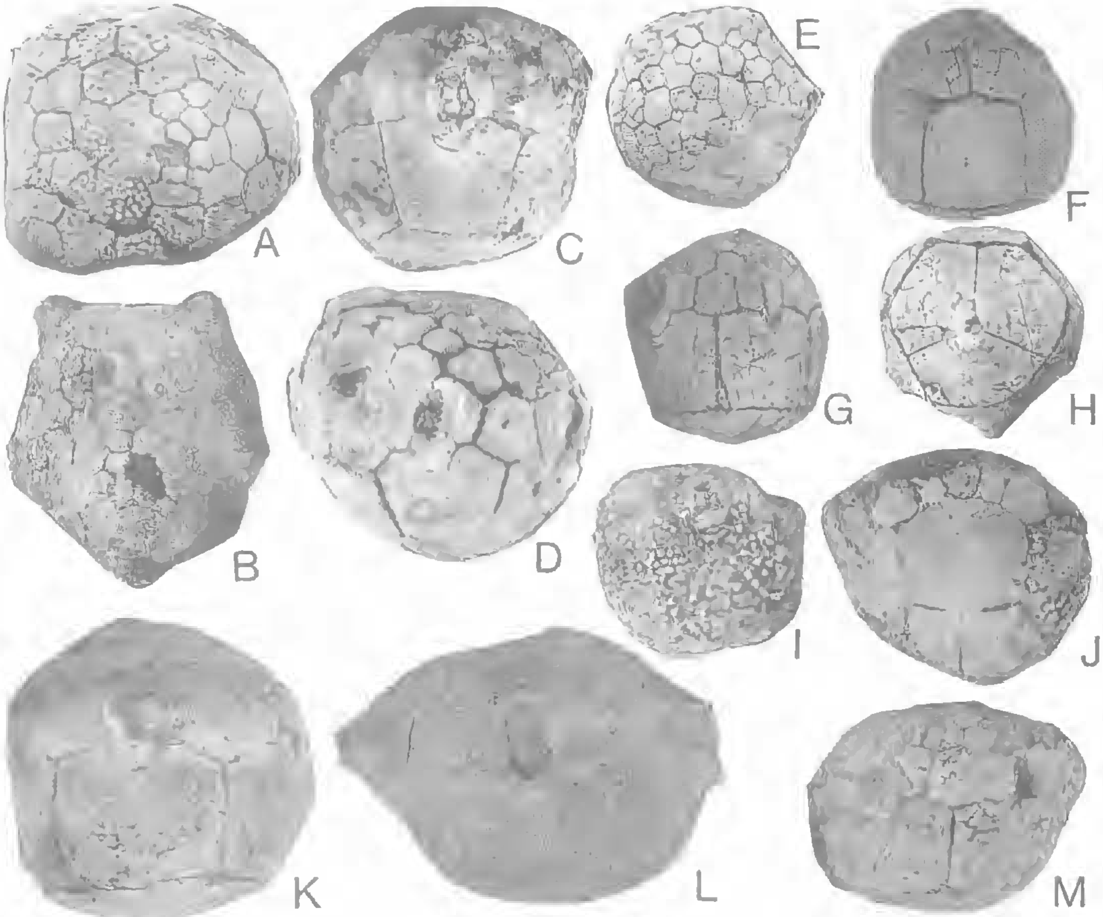


FIG. 11. *Hexacrinites interscapularis* Phillips, 1841. A, tegmen, incomplete on left side QMF14580, × 1. B,L, tegmen with A ray in 11 o'clock position and lateral view in E ray of large calyx UQF75128, × 1.5. C, lateral view in A ray UQF75130, × 1.5. D, oblique lateral view in C ray of small specimen UQF75121, × 1.5. E–H, tegminal with A ray in 3 o'clock position, lateral in C–D interray, lateral in A–E interray and basal (with A ray in 6 o'clock position) views of smoothed off calyx respectively, QMF14594, × 1. I, lateral view in B ray of small calyx showing well-developed ornament UQF75129, × 1. J, lateral view of small weathered specimen (orientation uncertain) UQF75123, × 1.5. K, lateral view in B ray of large calyx UQF75125, × 1. M, lateral view in A–E interray of small calyx UQF75120, × 1.5.

be interpreted as a reaction to some early damage to the individual that resulted in an extra growth centre albeit a small and irregular one.

Hexacrinites spinosus Muller, 1856
(Fig. 12A–F)

MATERIAL EXAMINED

Holotype Muller, 1856, pl. 1, fig. 13, Queensland Material UQF75110 from UQL5257; UQF75117 from UQL5317; QMF14746 from UQL5277.

OCCURRENCE

Givetian, Papilio Formation, near Storm Dam, on Wando Vale Station, north Queensland.

DESCRIPTION

Calyx bowl-shaped of medium height with strongly convex base. Basal circlet hexagonal, of 3 equal plates, with moderately large stem attachment area relative to size of plates. Radial plates large, parallel-sided to slightly expanding upwards, with horizontal lower margin and upper margin rising from lateral corners only a

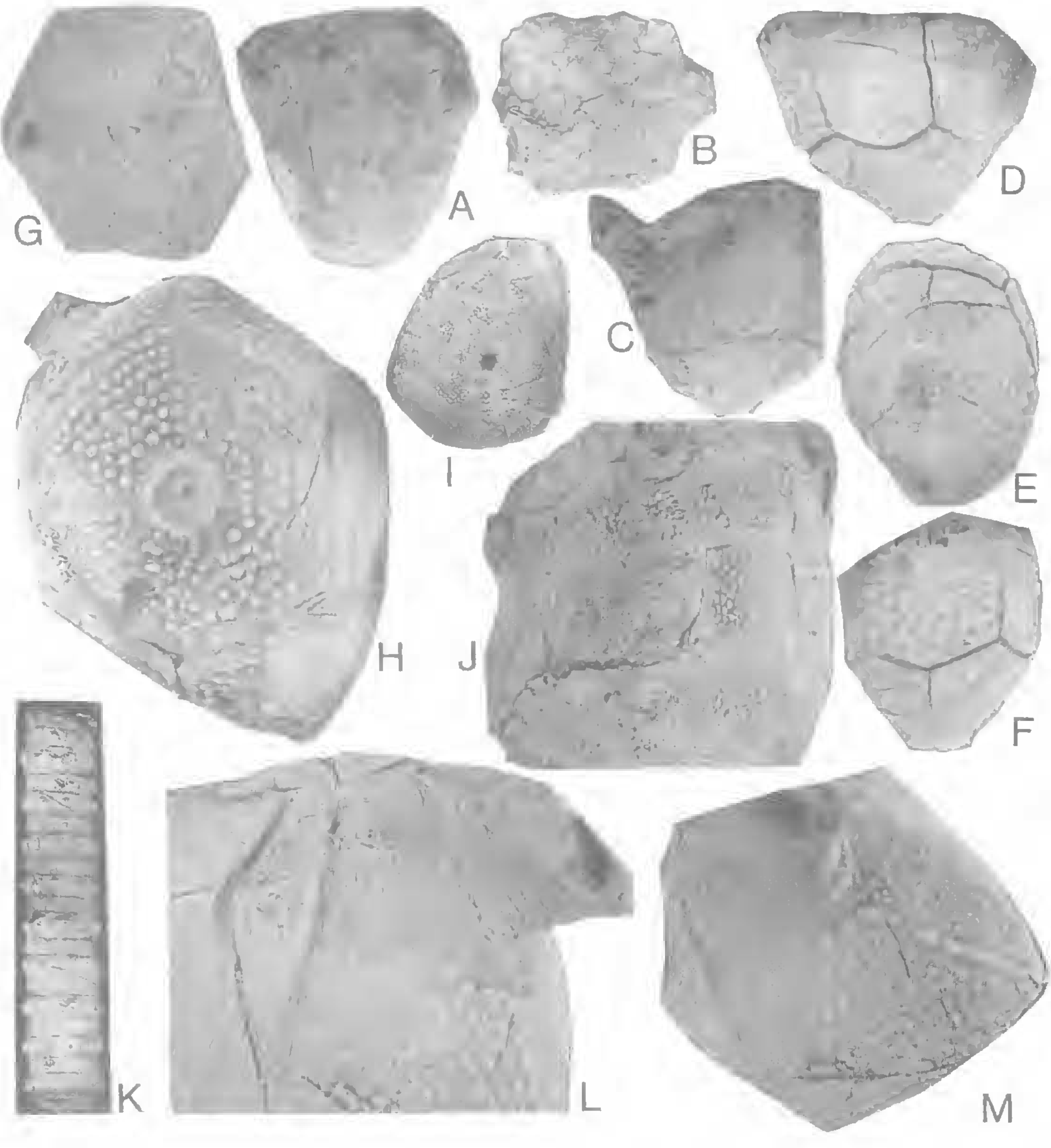


FIG. 12A–F, *Hexacrinites spinosus* Muller 1856. A,B, lateral in C– D interray and tegminal (with A ray in 3 o'clock position) views UQF75110, × 1.1. C, lateral view of incomplete calyx UQF75117, × 1. D–F, lateral, basal and lateral views, respectively, of incomplete calyx (orientation uncertain) QMF14746, × 1.8. G–M, *Hexacrinites interscapularis* Phillips, 1841. G, basal view of weathered calyx showing triangular section of axial canal towards inner surface of basal plates QMF14755, × 2. H, basal view of unweathered calyx with C ray in 11 o'clock position, showing very small axial canal and prominent rim around stem attachment area QMF14763, × 1.5. I,J, Basal with A ray in 12 o'clock position and lateral (A ray) views respectively, of large calyx with aberrant plate on lower right corner of radial UQF75125, × 0.75 and × 2, respectively. K, length of stem UQF75168, × 1.5. L,M, lateral view of free B ray arm base and lateral view of radial plate to which it is attached, respectively, QMF14834, × 2.

short distance to relatively wide arm insertion. First primibrach axillary, low, extending laterally to butt against interprimibrach. First secundibrachs (as a pair) of similar dimensions to first. Remainder of arms unknown. Primanal similar in size to radial, but slightly narrower, with broad V-shaped lower margin and irregular upper margin suporting 5 or 6 tegminal plates. A single large interbrachial rests on the radial circlet in each of the other interradii and is marginal to the two adjacent arms and 5 or 6 smaller tegminal plates. Tegmen convex, equal in height to radial circlet, of numerous relatively large plates, with a central pinnacle and depressed anal opening well posterior not far from margin in oral view. Ornament on plates of irregular tubercles commonly elongate on radials to give a maze pattern.

DISCUSSION

This material is closely comparable with the German species in distinctive features such as tegminal plating (cf. Schultze, 1867, pl. 8, fig. 2f) (Fig. 12B), basal arm branching, calycal shape, position of anal opening and ornament. No differences have been observed.

Suborder Glyptocrinina
Superfamily Melocrinitoidea
Family Melocrinitidae d'Orbigny, 1852

Melocrinites Goldfuss, 1831

TYPE SPECIES

Melocrinites heiroglyphicus Goldfuss, 1831 by subsequent designation of Roemer, 1855 from the Late Devonian of western Europe.

DISCUSSION

We follow Kesling (1964) in considering *Ctenocrinus* Bronn, 1840 to be a synonym of *Melocrinites.* At the same time we acknowledge that the presence or absence of outer rami on each ray (probably first outer ramule fixed in cup) allows most specimens of this group to be separated into two readily recognizable groups. Such subdivisions may be useful in discussions of evolutionary trends (e.g. Brower, 1976) and at best may be considered subgenera at the present time. In terms of this subdivision the north Queensland species would be assigned to *Melocrinites* whereas that from Wellington would belong to *Ctenocrinus.*

Melocrinites tempestus sp. nov.
(Figs 13A–H, 14A)

ETYMOLOGY

From Latin *tempestas* — a storm; for Storm Dam adjacent to the type locality.

MATERIAL EXAMINED

Holotype QMF14844 a complete calyx from UQL5218. Paratypes UQF75108, an incomplete calyx from UQL4443, and QMF14853 and 14854 from UQL5318/69.

OCCURRENCE

Givetian, Papilio Formation, near Storm Dam, Wando Vale Station, north Queensland.

DIAGNOSIS

Member of *Melocrinites* with tall conical calyx having ornament of widely spaced, low tubercles on calical plates; tall radial and primibrach plates; high narrow first secundibrach relative to wide low second secundibrach; flat tegmen and high narrow arms widely separated from each other.

DESCRIPTION

Calyx tall, conical, with convex base, less than 25mm in greatest diameter and almost 30mm in height; surface of plates flat except for narrow marginal band that descends to suture and smooth except for inconspicuous ornament of large, low, widely spaced tubercles.

Basal circlet of 4 plates, with interplate sutures in A, C, D and E rays, of at least 4mm height. Radial circlet of 5, large, contiguous plates, 9mm high and 8mm wide at the widest point 3mm from the top, with 7 sides including horizontal upper margin and broadly chevron shaped basal margin. First primibrach 6-sided, with horizontal upper and lower margins, 7mm high by 6mm at greatest width near midheight. Second primibrach axillary, 7-sided, 4mm high and 4mm wide each at greatest extent of that dimension. First secundibrach high but narrow relative to succeeding secundibrachs which become progressively lower, remain uniserial, but fuse with the other arm of the same ray to

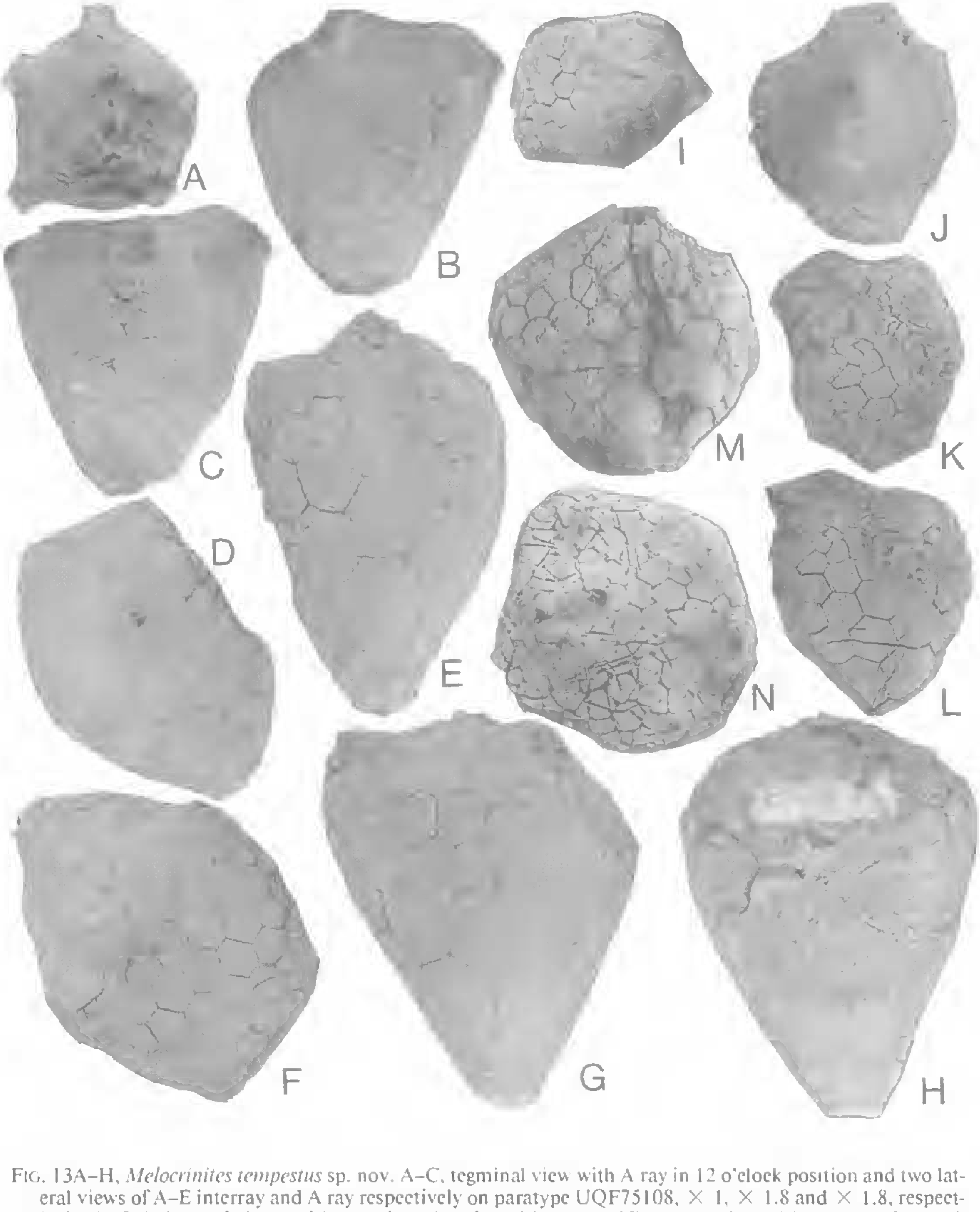


FIG. 13A–H, *Melocrinites tempestus* sp. nov. A–C, tegminal view with A ray in 12 o'clock position and two lateral views of A–E interray and A ray respectively on paratype UQF75108, × 1, × 1.8 and × 1.8, respectively. D–G, holotype in basal with A ray in 1 o'clock position, lateral D ray, tegminal with D ray at 10 o'clock and lateral (C–D interray) views, respectively, QMF14844, × 2. H, lateral view of paratype in C–D interray QMF14854, × 2. I–L, *Melocrinites solus* sp. nov. I–L, tegminal with A ray at 10 o'clock position, lateral C ray, lateral oblique A–B interray and lateral A–B interray views respectively of holotype AMF72519, × 1.2. M,N, lateral C ray and tegminal with D ray at 10 o'clock position views respectively, of paratype AMF72520, × 1.5.

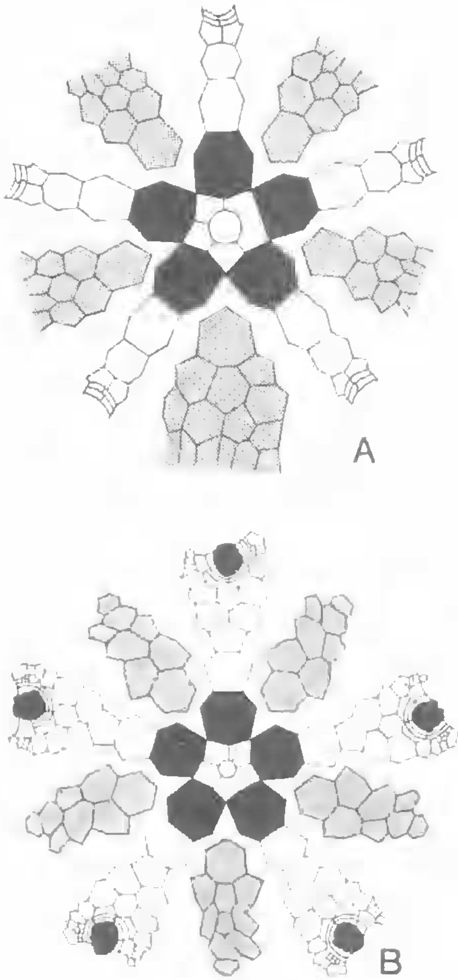


FIG. 14. Plate diagrams of A, *Melocrinites tempestus* sp. nov. and B, *Melocrinites solus* sp. nov.

form a single biserial ray trunk. Free arms not preserved but proximal portion high (7mm) and narrow (4mm) compared to other species of the genus. Intersecundibrachs not present. Interprimibrachs of a single large (7mm high by 6mm wide) plate at base, succeeded by 2 plates in the second range, then 3 in the third, and 4 in the fourth. Primanal 7-sided, supporting 3 secundanals then a larger number of irregular plates above. Tegmen almost flat, anal opening not evident.

REMARKS

This species resembles *M. aequus* Schmidt, 1942 from the Middle Devonian of Germany and *M. bainbridgensis* (Hall & Whitfield, 1875) from the Middle Devonian of New York and Ohio. but differs from the former in ornament on plates, relative height of primibrachs, and number and arrangement of upper interprimibrachs and differs from the latter in the shape of primibrachs.

Melocrinites solus sp. nov.
(Figs 13I–L, 14B)

ETYMOLOGY

From Latin *solus* — alone; referring to single large intersecundibrach in each ray.

MATERIAL EXAMINED

Holotype AMF72519 and paratype AMF72520 from QML512.

OCCURRENCE

Pragian (*sulcatus* biozone), Garra Formation, near Wellington, central New South Wales.

DIAGNOSIS

Member of *Melocrinites* with median ray ridges extremely poorly defined as broadly angular corners to calyx; smooth but convex calical plates; a single large intersecundibrach in each ray; small outer arms in each ray fixed in calyx for their basal part; single large intertertibrach; small number of interprimibrachs (5–7); 3 secundanals; flat tegmen except for a fairly high anal pyramid situated almost centrally.

DESCRIPTION

Calyx of medium height, conical, with convex base, 15% higher than wide; surface of plates smooth, gently convex, with median ray ridges poorly developed and evident only as five broadly angular corners to calyx. Basal circlet of 4 plates, with interplate sutures in A, B, C and E rays, with basals evident laterally and almost vertical. Radials in contact laterally, 7-sided, as high as wide, with two lower sides at extremely large angle to each other and upper margin horizontal; first primibrach hexagonal, slightly wider than high, with greatest width near top; second primibrach pentagonal, axillary, with barely convex sutural margins. Secundibrachs 2 in each arm, hexagonal but somewhat variable in shape from arm to arm, with single, large, hexagonal intersecundibrach between upper axillary ones. Tertibrachs of inner arms low and wide, strongly in contact above intersecundibrach and presumably extending through free arm giving a biserial appearance; in outer arms of each ray tertibrachs smaller but more or less equidimensional, 2 or 3 per arm, separated from main inner arm by 1 or 2 relatively large intertertibrachs. Interprimibrachs fewer than 10 per interray, with single hexagonal plate at bottom of each interray resting on two radials, followed above by 3 rows of 2 plates each that are 6- or 7-sided, usually a single narrow plate if any at all between free arm bases. C–D interray with single large 7-sided primanal resting on two radials, with 3 secundanals and succeeding rows decreasing (3,2,1) upwards. Tegmen of relatively large polygonal plates irregularly arranged and only gently convex, with prominent anal tube rising strongly and situated just behind centre. Free arms and stem unknown.

Remarks

Almost all taxa previously described as *Ctenocrinus* are distinguished from *M. solus* in exhibiting some form of stellate ornament and/or median ray ridges on calical plates. The smooth species *C. rhenanus* Follmann, 1887 may be distinguished by its lack of intersecundibrachs. *Ctenocrinus loricatus* Schmidt, 1942 has very small intersecundibrachs and has depressed corners on its calical plates. Another smooth specimen was figured by Wachsmuth & Springer (1897, pl. 23, fig. 5) as *Melocrinites bainbridgensis* but it was later assigned to *Melocrinites clarkei* Goldring, 1923 (Bassler & Moodey, 1943); it may be distinguished by its large intersecundibrach.

Superfamily Eucalyptocrinitoidea
Family Eucalyptocrinitidae Roemer, 1855

Eucalyptocrinites Goldfuss, 1831

Type Species

Eucalyptocrinites rosaceus Goldfuss, 1831 from the Eifelian of Germany by original designation.

Diagnosis

See Ubaghs (1978, p.495).

Discussion

Eucalyptocrinites is diverse and common in the Silurian of Europe and North America (Bassler & Moody, 1943; Webster, 1973, 1977) but only the type species from Germany and a species from USSR have been described from the Northern Hemisphere Devonian. Philip (1961) described the first species from the Southern Hemisphere among the crinoids of the Emsian Toongabbie Limestone of Victoria. The genus seems to be widespread in the early Devonian of eastern Australia despite the small number of identifiable specimens which is apparently due to poor preservation and/or lack of collecting effort. For example Griffith's Quarry near Mansfield yields a massive crinoidal limestone which never fractures around the specimen but many very tall crowns are broken through and several specimens in collections of the Museum of Victoria almost certainly belong to *E. fonzi* sp. nov.; George Sweet's specimen, the holotype, may be taken to be an extremely lucky break perhaps from a part of the quarry being worked at the time, 80 years ago, and subsequently filled in or totally removed.

Reduction in the number of primibrachs from 2 to 1 (Witzke & Strimple, 1981) occurred during the history of the family. Those authors also suggested that this trend recurred several times in allied lineages. *Chicagocrinus* Weller, 1900 exemplifies one such lineage in the Silurian Racine Dolomite of the Chicago District in which the first primibrach is lost and the second greatly reduced. Interestingly, an associated species of *Eucalyptocrinites* (i.e. *E. depressus* Miller, 1880) has low first primibrach which might be expected to occur before the plate was lost altogether. A second example of this trend is in *Eucalyptocrinites* itself where *E. schultzei* sp. nov. and *E. fonzi* sp. nov. have both lost the first primibrach, but the second is in no way diminished.

The original description of *E. rosaceus* (Goldfuss, 1831, p. 214, pl. 64, fig. 7a–c) involved illustration of only one calyx which exhibits a low first primibrach and an axillary second primibrach. Subsequently, Schultze (1867) assigned specimens with a single large axillary primibrach sitting on each radial to the type species, *E. rosaceus*. One of these specimens has now become the standard illustration for the type species and indeed for the genus (see Ubaghs, 1978, fig. 299, 1a). The collection of specimens from New South Wales, here referred to *E. rosaceus* consistently exhibits 2 primibrachs with the first being quite low. On the other hand the specimen referred to *E. praerosaceus* Yakovlev, from north Queensland, although only a single representative, does have

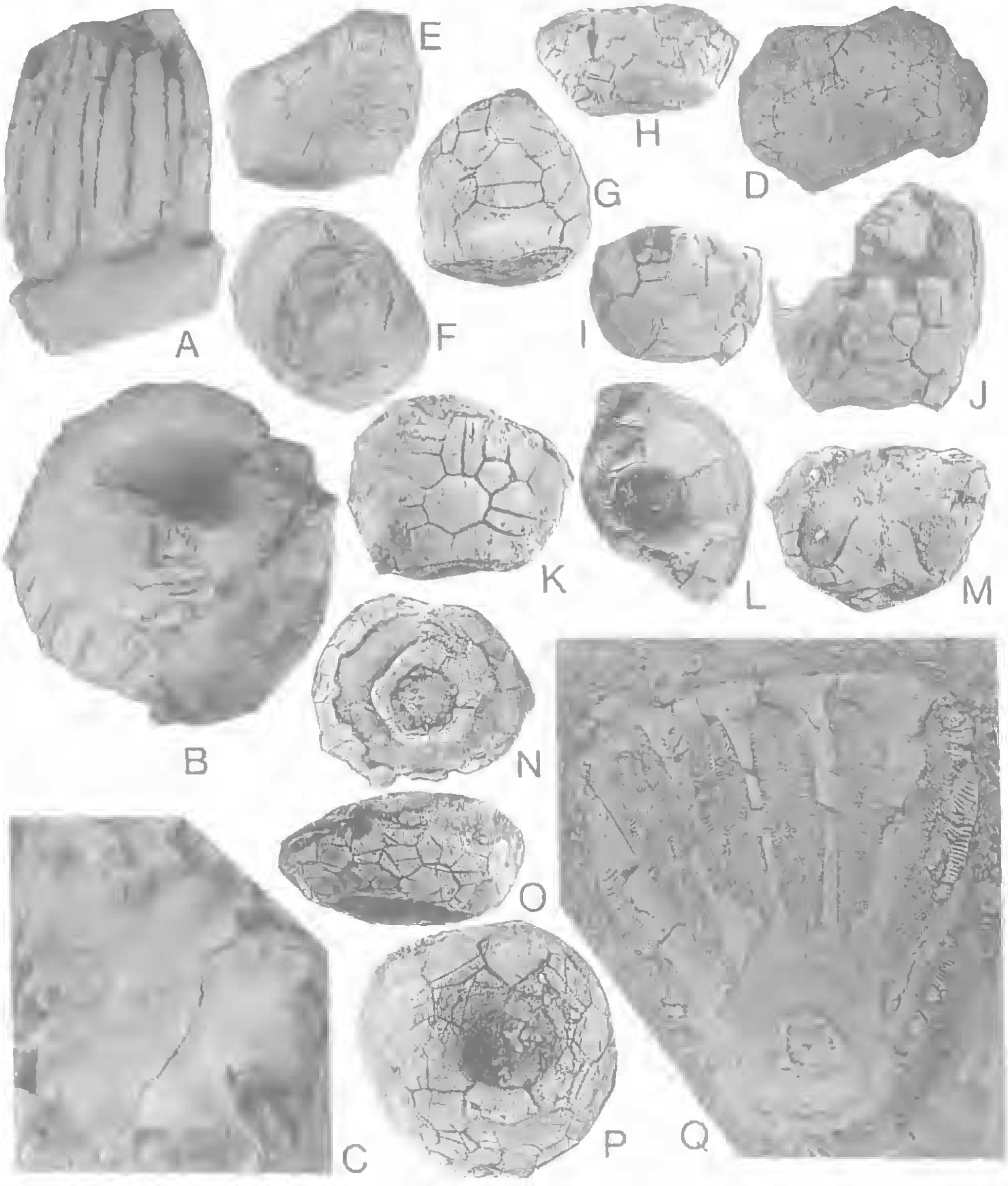


FIG. 15A–C, *Eucalyptocrinites fonzi* sp. nov. Holotype, NMVP109171, × 1.5. A, lateral view. B, basal view showing deep basal cavity and interprimibrach extending well down into basal depression. C, top of crown showing 6 plates centrally surrounded by upper surface of 10 tall columnal plates. D, *Eucalyptocrinites praerosaceus* Yakovlev, 1940 showing broad basal depression and plate margins difficult to distinguish from cleavage planes UQF75109, × 1.5. E–Q, *Eucalyptocrinites rosaceus* Goldfuss, 1831. E–G, lateral basal and lateral views respectively, QMF14546, × 1.5. H, lateral view of broad low calyx AMF72550, × 1.5. I,J, lateral views of weathered calyx AMF72546, × 1.5. K, lateral view AMF72552, × 1.5. L, basal view showing radials descending into basal depression AMF72553, × 1.5. M, naturally weathered vertical section of calyx showing height of basal depression and thickness of plates QMF14548, × 1.5. N, naturally weathered transverse section showing 5 radials on walls of basal depression AMF72549, × 1.5. O,P, lateral and basal views of low flaring calyx AMF72554, x1.5. Q, naturally weathered section through whole crown showing elongate vertical alcoves accommodating the free arms QMF14533, × 1.5.

only the single axillary primibrach. These observations lead us to the conclusion that the loss of the first primibrach is an evolutionary step that involved development of a separate species. The two species were apparently geographically isolated in Australia during the Pragian but sympatric in Germany during the Eifelian.

Eucalyptocrinites rosaceus Goldfuss, 1831
(Figs 15E–Q, 16A)

Eucalyptocrinites rosaceus Goldfuss, 1831, p. 214, pl. 64, fig. 7.
Eucalyptocrinites rosaceus Goldfuss; Schultze, 1867, p. 202, pl. 11, figs 6, 7 (not figs 1–5).

Material Examined

Holotype Goldfuss, 1831, pl. 64, fig. 7. Other figured material includes Schultze, 1867, pl. 11, figs 5–7. Australian material assigned includes AMF72543–72550 and 72552–72554 and QMF14533, 14541, 14544, 14546, 14548, from QML512.

Australian Occurrence

Pragian (*sulcatus* biozone), Garra Formation, near Wellington, central New South Wales.

Diagnosis

Member of *Eucalyptocrinites* with most of radial plates in basal depression; upper suture on radial arcuate and concave; first primibrach a low wide rectangular plate; second primibrach large and axillary; single tall intersecundibrach present; arms housed in alcoves separated by pillar-like plates rising above interprimibrachs and intersecundibrachs; upper plates with flattened upper surfaces.

Description

Calyx of medium height, cone-shaped, with depressed base, approximately 20mm in diameter and 12mm high. Basal depression relatively small, of only 6mm diameter; full depth not exposed. On holotype sides of the calyx stand up steeply whereas on AMF72554 the calyx flares out to lowest tertibrachs. Radials with much of plate outside basal depression, with widest point (12mm) relatively high on plate and on side of calyx, with curved concave upper margin. First primibrach 7mm wide by 1 or 2mm high, with concave lateral and lower margins and horizontal upper margin, usually subrectangular but

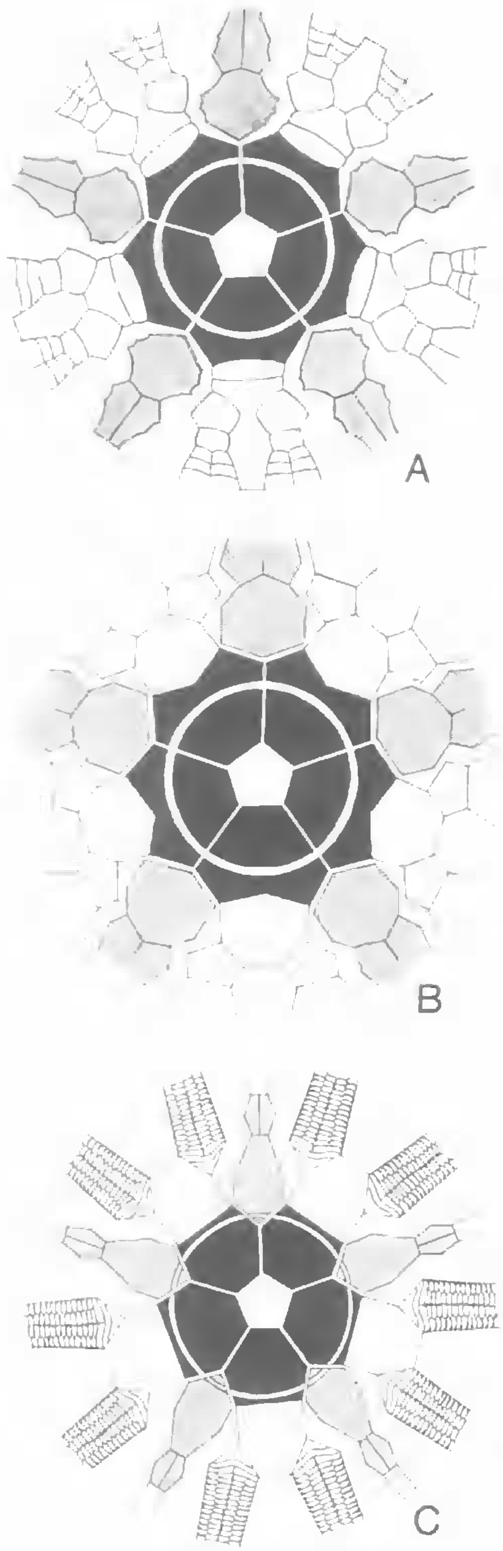


Fig. 16. Plate diagrams of A, *Eucalyptocrinites rosaceus*, B, *E. praerosaceus* and C, *E. fonzi*.

often irregular in shape with height on one side often decreasing to almost nothing. Second primibrach axillary, hexagonal, wider than high (6mm by 4mm in holotype), with horizontal upper margin supporting high large intersecundibrach that reaches same height as second row of interprimibrachs, with other two upper sides concave and supporting pentagonal first secundibrachs that are wider than high. Second secundibrach rectangular, axillary and each supporting a pair of quadrate tertibrachs. Interprimibrachs beginning with 10-sided plate of variable size but up to 7mm wide by 6mm high, with some concave sutural edges especially against first secundibrachs, and supporting pair of large high plates above. Second row of interprimibrachs at least 6mm high, 6-sided, with central vertical plane of symmetry between the two, forming a deep alcove with the intersecundibrach for the lower tertibrachs.

Higher parts of crown and all stem unknown.

Eucalyptocrinites praerosaceus
Yakovlev, 1940
(Figs 15D, 16B)

Eucalyptocrinites rosaceus Goldfuss; Schultze, 1867, pl. 11, figs 1, 2, 2a (not figs 5–7).
Eucalyptocrinites praerosaceus Yakovlev, 1940, p. 193.
Eucalyptocrinites rosaceus Goldfuss; Moore & Laudon, 1943, p.
Eucalyptocrinites rosaceus Goldfuss; Ubaghs, 1978, fig. 299, 1a– c.

MATERIAL EXAMINED

Holotype Yakovlev, 1940, fig. 1. One fragment of a calyx, UQF75109 from UQL3574.

AUSTRALIAN OCCURRENCE

Pragian (*sulcatus* biozone), Shield Creek Formation, near Old Pandanus Creek Homestead, north Queensland.

DIAGNOSIS

Member of *Eucalyptocrinites* resembling type species but with single axillary primibrach.

DESCRIPTION

Basal depression 5mm deep and 12–14mm in diameter with maximum diameter of calyx at level of top of radial circlet approximately 24mm. Basals not evident. Radials in contact with each other around lower part of calyx; part of radial evident laterally, having six sides, supporting first primibrach centrally and lowest interprimibrach in conjunction with adjoining radial; 7.5mm wide at widest point and 2mm high above base. First primibrach 4.2mm high and 5.5mm wide, 7-sided, with broad base, axillary, supporting two arms and large intersecundibrach; first secundibrach pentagonal, 4mm wide by 3.5mm high, with horizontal upper margin supporting low (1mm high) wide secundibrach nestled between tall large interprimibrachs and the large intersecundibrach. First interprimibrach 6mm wide and 5mm high, not extending into basal depression, 8-sided, supporting two very thick high plates above. Stem and higher parts of crown not available.

REMARKS

This one incomplete fragment of a calyx resembles *E. praerosaceus* in all observable features including the position of the radial plates extending well into the basal depression, relative sizes and shapes of calical plates and the first primibrach being axillary. However, the depth of the basal depression is proportionally greater in European material (see Schultze, 1867, pl. 11, fig. 2) where the deepest part is higher than the secundibrachs whereas in the Queensland specimen it is much lower; calical plates in previously described material are convex with broad low tubercles on most specimens whereas the Queensland specimen has smooth plates that may be so through weathering; and the features of the upper arms etc. are not known on the Queensland specimen. With these reservations and in the belief that the depth of the basal depression may vary within the species we make tentative assignment to the Eurasian species. It should be noted that occurrences of this species are of comparable age.

Eucalyptocrinites fonzi sp. nov.
(Figs 15A–C, 16C)

ETYMOLOGY

For Alphonse H.M. Vandenberg, of the Geological Survey of Victoria, who first guided the senior author to the Loyola Limestone.

MATERIAL EXAMINED

Holotype NMVP109171A and B, part and counterpart of a complete crown that is tectonically distorted, fractured and not fully freed from matrix. It was collected by George Sweet from Griffith's Quarry near Mansfield, Victoria.

Occurrence

Pragian (*kindlei* biozone), Loyola Limestone lens of the Norton Gully Sandstone, southwest of Mansfield, central Victoria.

Diagnosis

Member of *Eucalyptocrinites* with its first interprimibrach extending well into the basal depression, with hexagonal and axillary first primibrach and with five anal plates centrally on the upper surface of the crown and one accessory anal plate inside the circlet of 10 flattened tops to the pillar-like plates between the arms.

Description

Crown approximately 35–40mm high and 25mm in diameter. Calyx of medium height (8mm), conical with strongly depressed base. Basal depression wide, more than 12mm in diameter, of greater depth than height of calyx. Radials situated almost entirely within basal depression, having horizontal upper sutural margin barely on outer side of basal rim. First primibrach 7mm wide and 6mm high, hexagonal, axillary, bearing large intersecundibrach centrally and two pentagonal secundibrachs each supporting a curved second secundibrach on the concave upper margin. Second secundibrach axillary, extremely low and wide, set into slightly depressed alcove and broadly arcuate in shape. Arms becoming biserial above first tertibrach, tapering only gently, set into alcoves formed by tall pillar-like plates extending up from intersecundibrach and from interprimibrachs. These tall plates expand again distally to complete alcoves and then are capped by more or less flat plates in a circlet of ten surrounding six anal plates on distal end of crown. Anal plates in circlet of 4 hexagonal and one 7-sided plate surrounding central opening as well as a single pentagonal plate at the outer edge of the central circlet. First interprimibrach extending well into basal depression with its basal tip, hexagonal and relatively large, supporting pair of very high plates in second row which in turn support pillar-like plates extending to the top of the crown.

Remarks

Size of the basal depression, extension of first interprimibrach into basal depression, axillary first primibrach, single tertibrach and six anal plates, provide a unique combination of features among known species of the genus with none being closely comparable. The general plate arrangement is, however, consistent with that for the rest of the genus particularly the housing for the arms and upper surface of crown.

Superfamily Dolatocrinoidea

This superfamily, used by Ubaghs (1953, p. 742), includes the group of families that evolved from the Patelliocrinoidea and retained the three basal plates. We suggest that three families are involved and that the Pandanocrinidae gave rise to both the Polypeltidae and the Dolatocrinidae with development of different morphologies.

Family Polypeltidae Angelin, 1878

Polypeltid indet.
(Figs 19P, 20)

Material Examined

NMVP120789, a badly crushed and weathered calyx from NMVPL1958.

Occurrence

Pragian, Garra Formation, near Wellington, central New South Wales.

Discussion

The calyx is apparently bowl-shaped, with 10 free arms and only plates of upper part of calyx and tegmen evident on one side. Base of calyx is not evident upto axillary primibrach and interpretation of higher plates is open to two interpretations. There may be two columns of intersecundibrachs with lowest plate of each resting directly on axillary primibrach. Such an arrangement is rare and hence considered unlikely in this case. The other possibility is that the fixed secundibrachs are biserial, except for the first uniserial one, and there are no intersecundibrachs. Interprimibrachs are numerous, relatively small, in rows of 3 or 4 and upto 25 per interray. The tegmen consists of numerous irregular polygonal plates, apparently flat or slightly depressed. Free arms, stem and anal opening are not evident.

Affinity

These features suggest some resemblance to the Polypeltidae in respect of the fixed secundibrachs being numerous and going from uniserial to biserial, many interprimibrachs connecting to tegmen and few intersecundibrachs also connecting to tegmen. In particular the Early Devonian Spanish *Trybliocrinus* Geinitz, 1869 has a single uniserial secundibrach then biserial secundibrachs above and has many interprimibrachs. This Australian individual is distinguished from *Trybliocrinus* by its very few intersecundibrachs and large, apparently 7-sided, axillary primibrach. Although no other affinity is immediately apparent for this individual, its assignment to the Polypeltidae is speculative given the paucity of its diagnostic features.

Family Pandanocrinidae nov.

Diagnosis

Large camerate crinoids with arms free from early in secondary or tertiary brachitaxis (i.e. long series of secundibrachs or tertibrachs not fixed in cup), with hexagonal first primibrach, with relatively small numbers of interprimibrachs (i.e. upto 12), with no more than 5 or 6 intersecundibrachs if any at all, with 3 secundanals in C–D interray.

Discussion

We herein suggest that *Pandanocrinus* may be ancestral to both the Polypeltidae and Dolatocrinidae and that the combination of features above sets it apart from each at the family level; a few other crinoids are tentatively assigned to the family.

Indicating that these three families might be closely associated are general calical shape and size, 3 unequal basals, biserial arms (numbering 10 in at least some, usually the older, members), somewhat similar plate ornament in at least some members and other features shared by Pandanocrinidae and Dolatocrinidae on the one hand and Pandanocrinidae and Polypeltidae on the other.

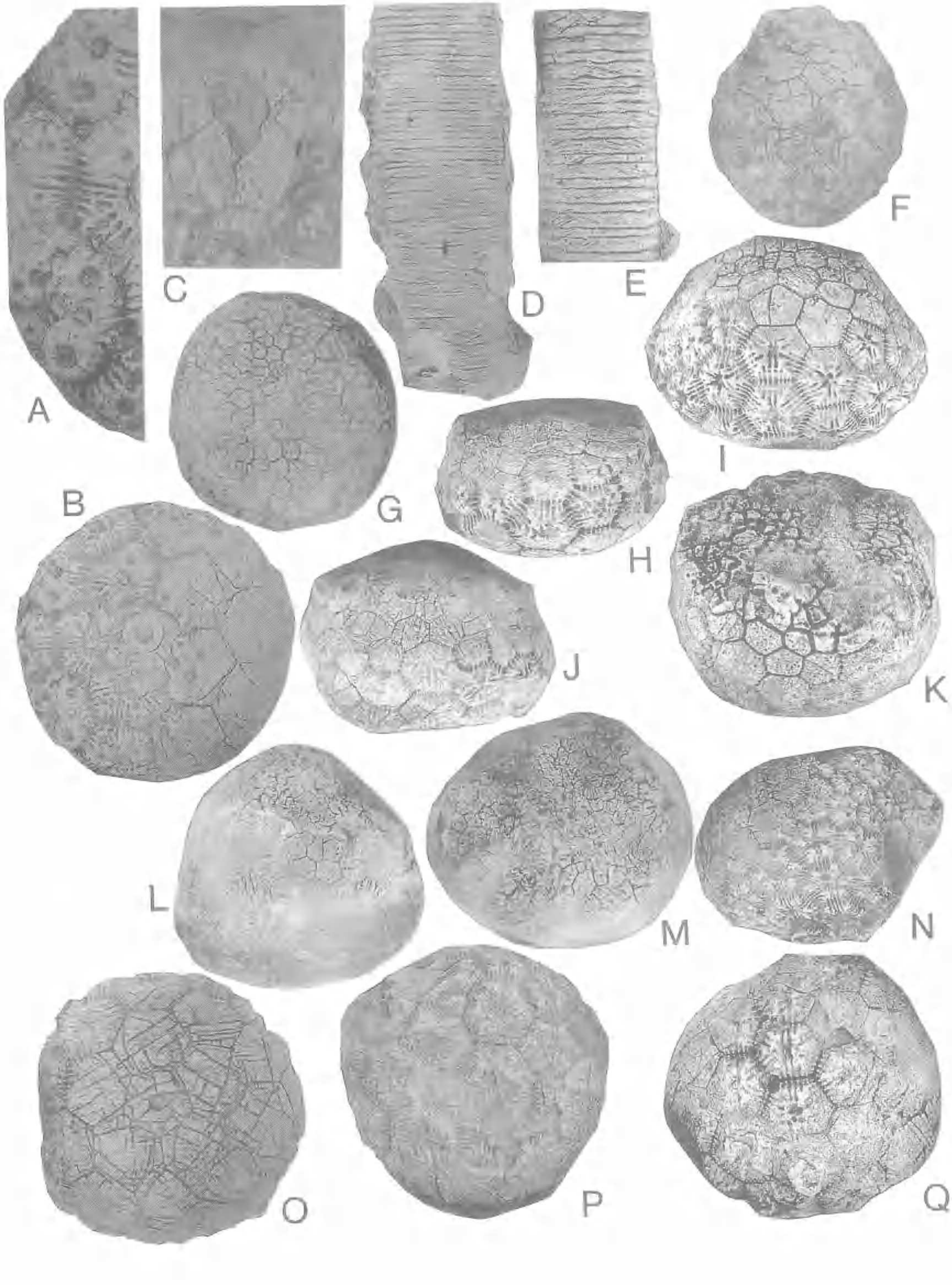
Understanding the origin of this group depends on the concept of the Patelliocrinoidea which is not very clear at present (Witzke & Strimple, 1981; Ausich, 1985). However, we do suggest that the Pandanocrinidae evolved from some member of the Patelliocrinidae probably in the Early or Middle Silurian.

From the Pandanocrinidae one lineage leads to the Polypeltidae attended by great increase in the number of fixed calical plates particularly in the brachials and interbrachials, by retention of the hexagonal first primibrach and differentiated C–D interray with three secundanals. The second lineage from the Pandanocrinidae leads to the Dolatocrinidae with development of the quadrate first primibrach and undifferentiated C–D interray in the species of *Dolatocrinus* itself (most other members of the family retain the differentiated anal interray) and retention or slight decrease in the number of calical plates and cup shape.

Some species at present assigned to *Technocrinus* Hall 1859. have 3 rather than 4 basals and are included in the Pandanocrinidae. One such species is *T. niagarensis* from the Upper Silurian (Pridolian) Decatur Limestone of Tennessee (Springer, 1921, p. 14, pl. 5, fig. 1). Plate ornament, calical plate shapes and sizes and particularly the 6-sided first primibrach ally this species with *Pandanocrinus*.

Moore & Laudon (1943) suggested the evolution of the Dolatocrinidae from the Clonocrinidae accompanied by a reduction in the number of basals from 4 to 3. Although that is a plausible proposal, evolution from the Pandanocrinidae seems more tenable; the num-

FIG. 17. *Pandanocrinus martinswellensis* gen. et sp. nov. A,B, enlargement (A) of part of basal view (B) with A ray in 11 o'clock position of large calyx showing circular borings UQF75174, × 2 and × 1 respectively. C, lateral view of free C ray arm base UQF75178, × 2.5. D,E, large stem sections with one (D) showing bases of large rootlets each with a central canal UQF75175, UQF75176 respectively, × 2. F, basal view of small badly weathered specimen (orientation uncertain) showing 3 basal plates UQF75177, × 1.2. G, tegminal view with A ray in 11 o'clock position showing numerous small polygonal plates with probable anal aperture situated peripherally near bottom UQF75178, × 1. H, lateral C ray view of holotype UQF75179, × 1. I,K, lateral views of calices (orientations uncertain) showing less common 5-sided second primibrach UQF75180, and 75182, × 1 and × 2, respectively. J, lateral D ray view of calyx weathered in upper part UQF75181, × 0.8. L,M, lateral and tegminal views (orientation uncertain) of weathered calyx with high-domed tegmen and five valleys in tegmen in interrays UQF75183, × 0.8. N, lateral view of fragment of calyx showing unweathered ornament UQF75184, × 0.6. O, basal view with B ray in 12 o'clock position of holotype showing 3 basal plates UQF75179, × 1.2. P, basal view with D ray in 2 o'clock position of large calyx showing aberrant development of a small triangular plate between radial and interprimibrach plates UQF75185, × 0.7. Q, lateral oblique view (orientation uncertain) of calyx showing fragment of proximal stem still attached and unweathered ornament UQF75186, × 1.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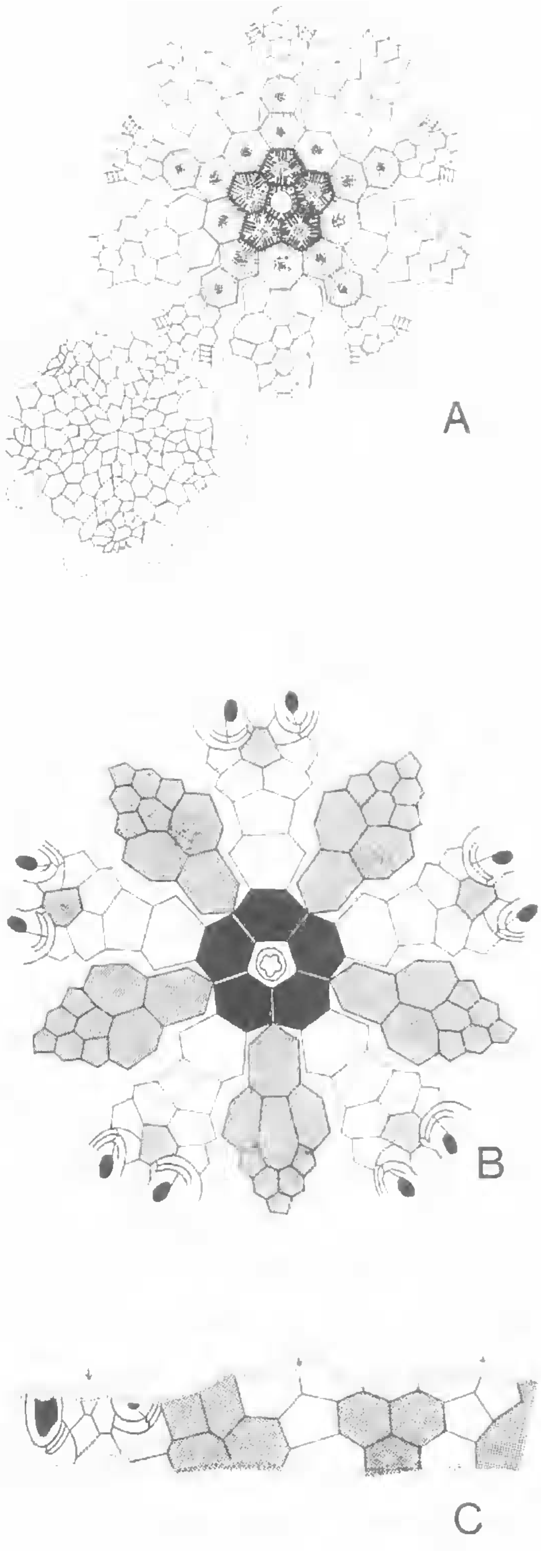


ber of basals remains constant, calical shape remains essentially low and flat bottomed, number of plates decreases as they move up out of the cup. Other lineages suggested by Moore & Laudon (1943) out of the Clonocrinidae retained the 4 basal plates and that stock is considered separate from the Dolatocrinoidea for this reason.

Pandanocrinus gen. nov.

ETYMOLOGY

Named for Pandanus Creek, the property on which the type locality occurs in north Queensland.

TYPE SPECIES

Pandanocrinus martinswellensis sp. nov. from the Pragian Martins Well Limestone Member, Shield Creek Formation, east of Pandanus Creek Homestead.

DIAGNOSIS

Large crinoid with bowl- to globe-shaped calyx of medium height and having a subhorizontal base. Basal circlet pentagonal, of three unequal plates, dividing sutures in A, E and C rays. Five hexagonal radials in lateral contact. First primibrach hexagonal, supporting large 5- or 7-sided axillary second primibrach. Arms biserial, 10 in number. Intersecundibrachs present. Interprimibrachs numerous (more than 10 in each interray), with 2 in second row except in posterior interray where large primanal supports 3 secundanals and usually a greater number of anals than there are interbrachials in other interrays. Tegmen of irregular polygonal plates, variable in height from slightly depressed to high domed; anal opening sub-central or peripheral posteriorly.

DISCUSSION

This genus has been distinguished and its relationships discussed in the family discussion above. It is the only certain member of the family at present.

FIG. 18. Plate diagrams of A, *Pandanocrinus martinswellensis* gen. et sp. nov. (including tegmen) drawn from holotype with more typical 7-sided second primibrach; B, *P. wellingtonensis* ge. et sp. nov. and C, *P.* sp. cf. *P. wellingtonensis* (drawn from Fig. 20A as far as revealed).

Pandanocrinus martinswellensis sp. nov.
(Figs 17, 18A, 19A–F)

Crinoid gen. et sp. nov. Hill, Playford & Woods, 1967, pl. D14, figs 9,10.

ETYMOLOGY
The species is named for Martins Well where it occurs in very large numbers (more than 300 calices have been collected there).

MATERIAL EXAMINED
Holotype UQF75179 from UQL3579. Paratypes UQF75174–75178, 75180–75191 from UQL3579. A further 200 specimens, from UQL3579, in the collections of University of Queensland, Queensland Museum and Museum of Victoria have been examined.

OCCURRENCE
Pragian (*sulcatus* biozone), Martins Well Limestone Member of the Shield Creek Formation, at Martins Well on Pandanus Creek Station, north Queensland.

DIAGNOSIS
Member of *Pandanocrinus* with free arms originating from the calyx at the second secundibrach; intersection of the subradial ornament on each plate producing a central, pitted, depressed area; five rays strongly defined by four or five ridges normal to the plate margin. Calyx averaging 30–40mm diameter with only a single individual attaining 60mm diameter.

DESCRIPTION
Calyx of medium height, globe-shaped, with subhorizontal base, of average size 40mm diameter with a range from 20–60mm diameter in available collections; variable height depending on whether tegmen is flat (Fig.17H) or inflated (Fig.17L); range in height 17–50mm. Ornament on calical plates up to first secundibrachs consisting of sets of 4–6 sharp ridges normal to each sutural margin, longer ridges medially on each suture, shorter ones laterally as they merge with adjacent sets; ridges forming triangular shapes around three way sutural intersections; central area with six sets of ridges intersecting expressed as area of small rounded pits and pitted area strongly depressed as whole with prominent crests (usually 6) at the high corners between sets of ridges.

Basal circlet pentagonal, of 3 unequal plates, with sutures in A, C and E rays with circular depressed stem attachment area occupying most of circlet and defined by a raised annulus. Radials hexagonal, with straight margins and in contact laterally along vertical sutures; each plate larger than entire basal circlet. First primibrach same size and shape as radial. Second axillary, 7-sided rarely 6-sided, only slightly smaller than first. First secundibrach hexagonal, usually rather low but variable in height between individuals. Second secundibrach also variable in height, often irregular in shape against interbrachials but generally irregularly hexagonal. Free arm originating from second secundibrach and apparently biserial from base as wedge-shaped plates evident at broken base. Intersecundibrachs usually 3 or 4 with one hexagonal plate in first range then two in next and one in third; although usually fairly symmetrical a few individuals show irregularly shaped intersecundibrachs. Interprimibrachs numerous, upto 16 in most interrays with a minimum of one extra in C–D interray; in all except C–D interray a large hexagonal plate is at the base supporting a second row of two large plates, with successive rows of 3 plates gradually decreasing in size up the calyx. C–D interray has a single large 7-sided plate at base supporting 3 plates in next row, then rows of 3 or 4 plates higher up. Tegmen of smaller polygonal plates, usually in the range 2–5mm in average sized individuals; may be flat, gently depressed or inflated to the extent of being half calical height in at least one specimen; often with broad shallow depressions radiating to the five interrays; with anal opening a discrete circular aperture in posterior interray about halfway from middle to circumference, may be recessed within radial depression.

Free arms not known. Stem circular, with ossicles of uniform height.

REMARKS
This species differs from *P. geuriensis* sp. nov. in its smaller size, number of secundibrachs and plate ornament.

A number of specimens exhibit numerous small circular pits in the calical plates at random positions (Fig. 17A,B); some are on sutures others are in the centre of plates while others are irregularly placed entirely within the plate boundaries. These pits may be attributed to the ichnogenus *Tremichnus paraboloides* Brett, 1985 formed by some epizoan organism that either inhibited stereom growth or actively

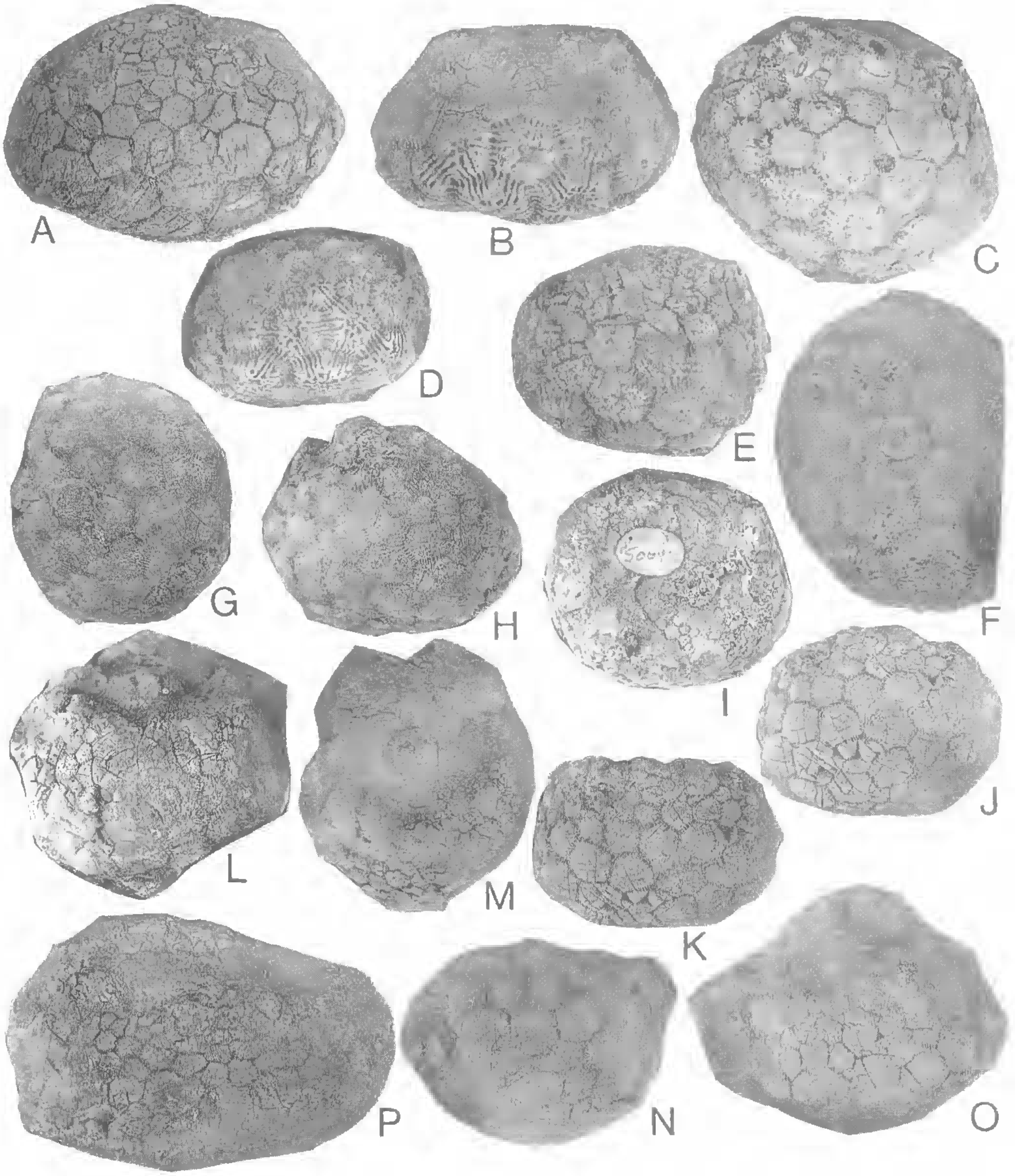


FIG. 19. A–F, *Pandanocrinus martinswellensis* gen. et sp. nov. A,B,D,E, lateral views in E–D, C–B, E–D and C–B interrays respectively of variously weathered calices showing unweathered ornament in parts and plate arrangement (E with C–D interray on extreme left of print), UQF75187, 75188, 75178, and 75190, respectively, × 1. C, lateral oblique view (orientation uncertain) of calyx showing base of free arm and boring excavating two plates UQF75189, × 1. F, basal view with A ray in 11 o'clock position of incomplete calyx with C–D interray at lower edge of print UQF75191, × 1. G–O, *Pandanocrinus geuriensis* gen. et sp. nov. (orientations uncertain) G,H, basal and lateral views of paratype calyx NMVP120771, × 0.6. I–K, tegminal, lateral oblique and lateral views of holotype calyx AMF50693, × 0.8. L,M, lateral oblique and tegminal views of weathered paratype calyx showing slightly depressed tegmen and base of central anal tube NMVP120770, × 0.6. N,O, lateral views of badly weathered paratype calices (N showing C–D interray on extreme right) NMVP120782 and 120777, respectively, × 0.6. P, Polypeltid indet. lateral view of incomplete, tectonically distorted calyx showing plating of upper parts only, NMVP120789, × 0.8.

bored into it either mechanically or chemically. This Australian example adds no more to the understanding of this ichnofossil but extends its distribution considerably.

Pandanocrinus geuriensis sp. nov.
(Fig. 19G–O)

ETYMOLOGY

For the town of Geurie, New South Wales near the type locality.

MATERIAL EXAMINED

Holotype AMF50693 an incomplete calyx from NMVPL1957, presented by Mr A. Graham of Dubbo in 1963. Paratypes NMVP120770–120786 from NMVPL1957, a series of rather poorly preserved calices in various degrees of weathering and a few stem fragments.

OCCURRENCE

Pragian or early Emsian, Garra Formation, near Geurie north of Wellington, central New South Wales.

DIAGNOSIS

Member of *Pandanocrinus* with free arms emanating from the calyx at the third or fourth secundibrach; radial ornament on each plate in sets of fine ridges normal to bounding sutures; centre of each plate strongly convex; attaining size of 70–80mm diameter with an average of 50–60mm.

DESCRIPTION

This species is described only where it differs from *P. martinswellensis*.

Calical shape is essentially the same but the tegmen is subhorizontal. On the basal circlet the raised annulus around the stem attachment area is closer to the outer margin of that circlet. There are a minimum of 3 fixed secundibrachs in each halfray; the 10 free arms originate from the third or fourth secundibrach. The intersecundibrachs are organized into two vertical columns above the pentagonal plate at the base of the series. The ornament on each calical plate involves the 5 sets of ridges normal to the sutures but the central area where they intersect is convex. It is larger, averaging 60mm in diameter as opposed to 40mm. On the stem are numerous strong cirral attachment areas.

REMARKS

It is generally poorly preserved due to weathering and adhereing matrix. The convex centres of calical plates are commonly smoothed off by weathering.

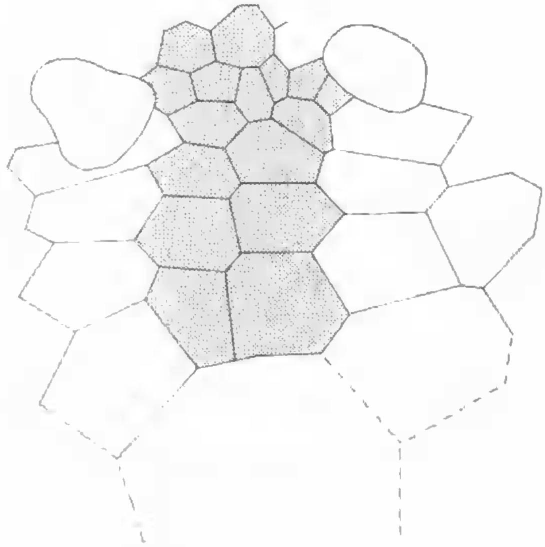


FIG. 20. Plate diagram of central part of Polypeltid indet. showing inferred double column of intersecundibrachs (shaded) (drawn from Fig. 19P).

Pandanocrinus wellingtonensis sp. nov.
(Figs 18B, 21C–K)

ETYMOLOGY

For the town of Wellington, New South Wales, adjacent to the type locality.

MATERIAL EXAMINED

Holotype AMF72539, paratypes AMF72529–72532, 72540, 72541 and QMF14532, 14537–14539, 14542 all from QML512. All are poorly preserved, incomplete and tectonically damaged calices.

OCCURRENCE

Pragian (*sulcatus* biozone), Garra Formation, near Wellington, central New South Wales.

DIAGNOSIS

Member of *Pandanocrinus* with low bowl-shaped calyx having sub-horizontal to gently depressed base; second primibrach pentagonal; two fixed secundibrachs; 10 biserial arms, with large intersecundibrachs; interprimibrachs relatively few in rows of two each after lowest larger plate. Tegmen of large polygonal plates; anal opening in C–D interray between arm bases; smooth broadly convex plates having low but distinct ridges normal to sutures in slight sutural depressions.

Description

Calyx of medium height, bowl-shaped, with sub-horizontal to slightly depressed base, ranging from 15–70mm in diameter; plates smooth and broadly convex, with depressed sutural margins, with discrete close spaced (1 per mm) ridges normal to sutures running from one plate to next. Basal circlet pentagonal, of three unequal plates, with sutures in A, E and C rays, occupied almost entirely by circular gently concave stem attachment area having pentalobate axial canal centrally; stem attachment with well-developed very fine crenularium. Radials hexagonal, wider than high, not quite as large as first primibrach, in contact laterally with each other. First primibrachs hexagonal, approximately same size as lowest interprimibrach and largest plates in calyx, just wider than high, with widest point above midheight. Second primibrach pentagonal, axillary, with similar maximum height and width. First secundibrach hexagonal, with longest sides on primibrach and parallel to it above. Second secundibrach much lower, wider, with concave upper margin. Third secundibrach low, fixed, becoming arcuate, with broad deep articulatory basins and becoming biserial. Interprimibrachs beginning with single large hexagonal plate, followed above by up to five rows of two hexagonal plates each. Intersecundibrachs resting on first secundibrachs, consisting of one large plate followed above by two smaller but taller plates, then a third row of two plates between free arm bases. C–D interray with 7-sided primanal; 3 secundanals with central tall one extending to top of tertanals which it separates, fourth row of anals above tall secundanal and immediately below deeply depressed anal opening between free arm bases. Tegmen of large convex polygonal plates, without clear differentiation of orals. Free arms and stem not available.

Remarks

This species is simply distinguished from *P. martinswellensis* and *P. geuriensis* by its pentagonal second primibrach, plate ornament, and organization of the interprimibrachs. There is some variation in calical shape but most of this may be attributed to tectonic distortion; smaller specimens tend to be higher relative to diameter than larger specimens.

Pandanocrinus sp. cf **P. wellingtonensis** sp. nov.
(Figs 18C, 21A,B)

Material Examined

UQF75170 and UQF75171 from UQL3522. These two calices are preserved as calcium carbonate embedded in a relatively clean, massive limestone; preparation to free them has not been attempted. Only a few plates are evident on each specimen

Occurrence

Lochkovian or Pragian, Mount Holly Beds, Mt Etna near Rockhampton, central Queensland.

Description

UQF75170 shows the bases of two free arms of the one ray with low wedge-shaped arm plates evident and with a single large intersecundibrach below the free arm bases supporting a pair of tall intersecundibrachs at the level of the free arm bases. The pentagonal axillary primibrach resting on an hexagonal primibrach is evident in the adjacent ray with 2 interprimibrachs between the axillary primibrachs followed above by another row of two plates. In the next adjacent interray the two interprimibrachs between the axillary primibrachs rest on an apparently hexagonal interprimibrach that is presumably the lowest.

UQF75171 suggests the low bowl-shaped calyx and also exhibits the pentagonal axillary primibrach, two interprimibrachs between them, the bottom of the large intersecundibrach and a weathered but apparently stellate plate ornament.

Discussion

These features are consistent with *Pandanocrinus wellingtonensis* except for the ornament which could possibly be the result of weathering although this seems unlikely. Among the species of *Pandanocrinus* the pentagonal axillary primibrach is distinctive of *wellingtonensis*. However, in the absence of information on several important features this assignment must remain speculative.

Family Dolatocrinidae Miller, 1890

Dolatocrinus Lyon, 1857

Type Species

Dolatocrinus lacus Lyon, 1857 from the Lower Devonian Jeffersonville Limestone in Kentucky, U.S.A. by original designation.

Discussion

As far as we are aware this genus has not previously been recorded outside North Amer-

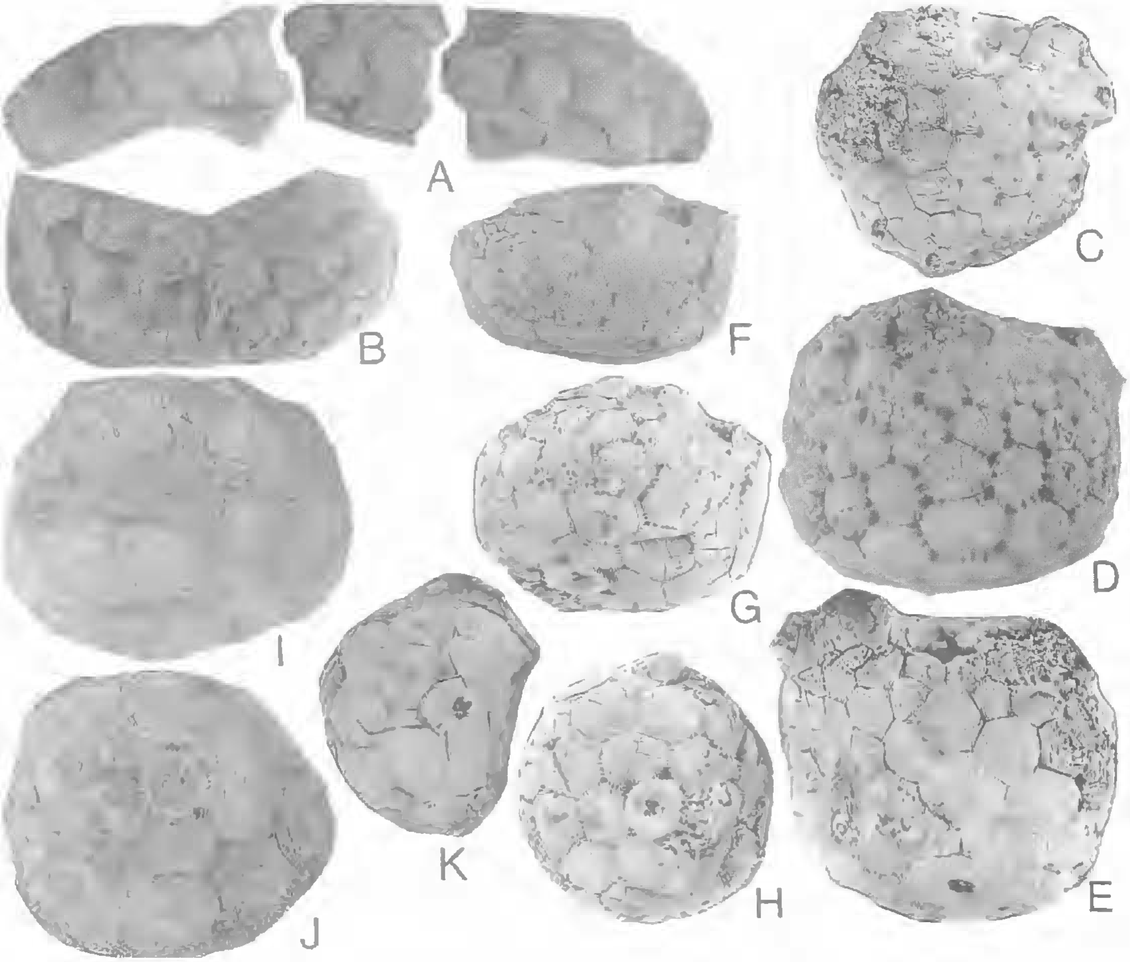


FIG. 21. A,B. *Pandanocrinus* sp. cf. *P. wellingtonensis* sp. nov. A, composite lateral view of only partly preserved and partly exposed calyx UQF75170, × 1.5. B. lateral view of incomplete calyx, UQF75171, × 1. C–K. *Pandanocrinus wellingtonensis* gen. et sp. nov. C–E, tegminal with D ray at 2 o'clock position, lateral B ray and lateral in C–D interray views of small paratype calyx AMF72540, × 2. F–H, lateral, lateral oblique and basal views (orientations uncertain) of holotype calyx AMF72539, × 0.7. I,J, lateral D ray and basal with D ray in 1 o'clock position views of large damaged paratype calyx AMF72541, × 0.7. K, basal view of incomplete paratype calyx showing 3 basal plates AMF72530, × 1.2.

ica. Its expanded distribution and the occurrence of its inferred ancestors and close relative, *Shimantocrinus*, in Australia are surprising when considered in terms of the rest of the Australian fauna.

Dolatocrinus peregrinus sp. nov.
(Figs 22, 23)

ETYMOLOGY

From Latin *peregrinus* — foreign, exotic; referring to this first record outside North America.

MATERIAL EXAMINED

Holotype QMF14818 from UQL5277. Paratypes QMF14866 and 14867 from UQL5320 and QMF14872 from UQL5321.

OCCURRENCE

Givetian, Papilio Formation, near Storm Dam, Wando Vale Station, north Queensland.

DIAGNOSIS

Member of *Dolatocrinus* with 10 arms; first secundibrach relatively large, extending as high as aperture for arm canal laterally and supporting second secundibrach from which free arm arises; with one or two pinnule apertures per arm, with one on interradial side always present and second on radial side when present in larger individuals; tegmen high domed; ornament on calical plates of raised reticulate ridges outlining a pattern of broad circular and elongate pits.

DESCRIPTION

Calyx ranging in size from 20–40mm diameter, low, bowl-shaped, with shallow basal depression. Calical ornament of raised reticulate ridges arranged randomly to define a pattern of broad circular and elongate pits, degenerating higher up the calyx between the free arm bases and on the tegmen.

Basal circlet pentagonal, almost completely concealed by large circular stem attachment area characterized by distinct fine crenularium; remainder of basal circlet occupied by prominent raised rim around attachment area; arrangement of basal plates concealed by stem attachment. Radial circlet of five 6-sided plates with concave upper margin supporting first primibrach, with widest point well above midheight and height to width ratio of nearly 1:2. First primibrach quadrate, with convex margins and height to width ratio of 1:2. Second primibrach pentagonal, axillary, with straight margins except for weakly concave lower margin on some specimens, with low lateral margins and height to width ratio of 1:2. Fixed secundibrachs two per arm; first rather large, as wide as base of second primibrach, L-shaped and extending well up the interradial side of the arm base; second secundibrach narrower, not extending as far interradially as first, and bearing the entire free arm base. Articulation on second secundibrach an immovable symplexy; 5 or 6 plates (3 or 4 tegminal plates) surround the central canal of each arm as it emerges from the calyx, central canal slightly elongate upwards in cross section; two large plates beneath axial canal quite thick, with concave articulating surface and bearing fine radiating crenellae; smaller plates above axial canal much smaller and thinner. Interprimibrachs arranged similarly in each interray with one large 9-sided plate resting on radials and supporting smaller 5 or 6-sided interprimibrach above, with this in turn supporting 2 or 3 plates in the third row and then the tegminal plates. Tegmen strongly domed, consisting of relatively large polygonal plates, irregularly arranged, with anal opening directly through tegmen situated asymmetrically. Free arms and stem unknown.

REMARKS

This species resembles *D. lacus* in many respects but is distinguished by the high tegmen, plate ornament and shape of first secundibrach. *Dolatocrinus grandis* Miller & Gurley, 1894 has similar calical ornament although radial nature of the ornament is generally more apparent in that species than in *D. peregrinus*; moreover, *D. grandis* has numerous pinnule apertures, usually has median ray ridges, has more than two fixed secundibrachs and a deep basal depression. Other 10-armed species are readily distinguished by their plate ornament and secundibrach arrangement.

All four specimens have suffered lateral compression to differing degrees and the holotype has been dorsoventrally compressed as well. Preservation of the material is not good enough to compare the specimens in all features and variations observed are probably due to growth rather than variation. The smallest individual (Fig.22F,G) has a pinnule aperture only on the interradial side of each arm base; relative height of the tegmen decreases with growth; the size of the second secundibrach increases relative to size of the first secundibrach; and the relative size of the third row of interprimibrachs decreases.

Shimantocrinus gen. nov.

ETYMOLOGY

An anagram from McIntosh plus the usual termination for crinoid genera. For Dr George C. McIntosh of the Rochester Museum and Science Center whose assistance in this study has been considerable.

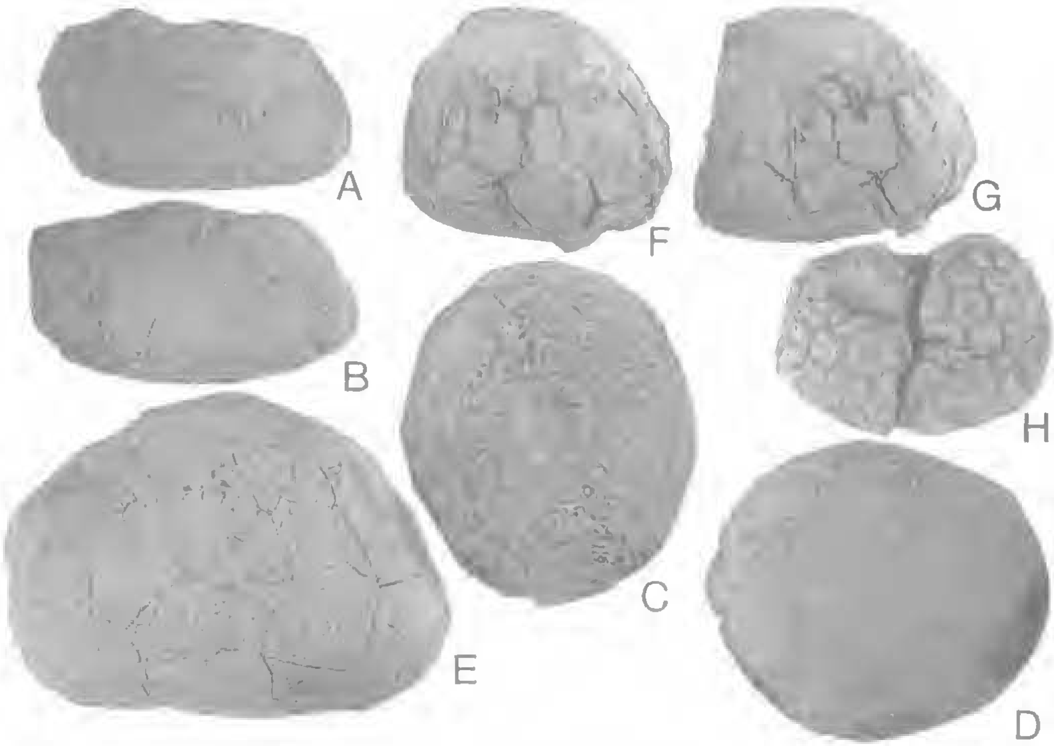


FIG. 22. *Dolatocrinus peregrinus* sp. nov. A–D, two lateral, basal and tegminal views, respectively, of holotype calyx QMF14818, × 1. E, lateral view of large paratype calyx showing pinnular apertures either side of free arm bases, QMF14866. × 1.5. F,G, lateral views of small incomplete paratype calyx showing pinnular aperture only on outer side of each free arm base, QMF14867, × 1.8. H, tegminal view of badly damaged paratype calyx QMF14872, × 1.

TYPE SPECIES

Shimantocrinus distinctodorsus sp. nov. Pragian (*sulcatus* biozone), Garra Formation, near Wellington, central New South Wales.

DIAGNOSIS

Member of Dolatocrinidae with low, globe-shaped, strongly lobate calyx wider than high, having concave base. Primibrachs 2 per ray, first one rectangular with convex margins except in C and D rays where it is pentagonal. Secundibrachs 3 or 4 fixed in each arm, becoming low and wedge-shaped after first. Intersecundibrachs not present. Arms 10 in number, biserial. Except in C–D interray interprimibrachs few, approximately 8 per interray; lowest in each interray a single, large, 10-sided plate supporting 2 interprimibrachs in second row. In C–D interray primanal 7-sided, supporting 3 large plates in second row, then numerous (upto 20) smaller plates above. Tegmen flat but strongly lobate, with steep, wide

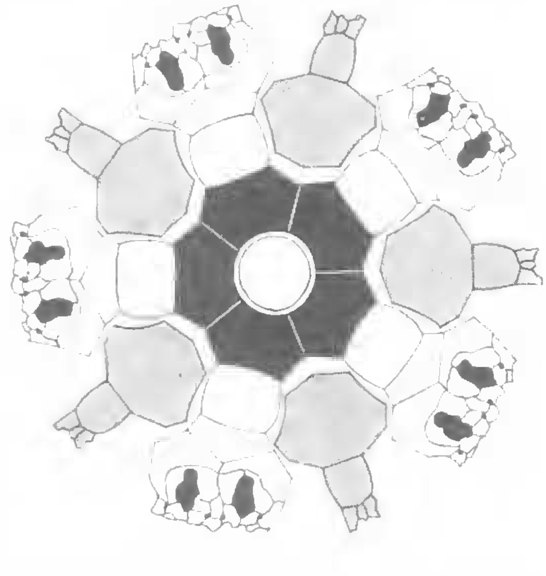


FIG. 23. Plate diagram of *Dolatocrinus peregrinus* sp. nov.

grooves running down between rays; with subcentral anal opening directly through flat-plated surface.

DISCUSSION

This genus is closely related to *Dolatocrinus* Lyon 1857 from the Early and Middle Devonian of North America but differs most significantly in having a strongly differentiated C–D interray. Springer (1921), Kesling & Mintz (1963) and Ubaghs (1978) all diagnosed *Dolatocrinus* as having an undifferentiated C–D interray. The monotypic patelliocrinid *Centriocrinus* is also closely similar in general form, number of arms, size and shape of radials and relatively few interprimibrachs but particularly if the C– D interray has 3 secundanals as quoted by Ubaghs (1978) contrary to the opinion of Wachsmuth & Springer (1897). It is distinguished by the apparently invariably hexagonal first primibrach which is more reminiscent of *Pandanocrinus*.

Shimantocrinus distinctodorsus sp. nov. (Figs 24, 25)

ETYMOLOGY

From Latin *distinctus* — different and *dorsum* n. — back; referring to differentiated posterior interray.

MATERIAL EXAMINED

Holotype AMF72537 from QML512. Paratypes AMF72533–72536, 72538 and QMF14536 and 14540 from QML512.

OCCURRENCE

Pragian (*sulcatus* biozone), Garra Formation, near Wellington, central New South Wales.

DIAGNOSIS

As for genus.

DESCRIPTION

Calyx low, globe-shaped, with depressed base; ornament of irregular anastamosing ridges normal to sutures in distinct furrows around each plate. Basal circlet pentagonal, of 3 unequal plates, with azygous plate in A–E interray and interplate sutures in A, C and E rays; depressed circular stem attachment area occupying almost all of this circlet, with central pentalobate axial canal evident (Fig. 24C), and marked annular rim becoming less prominent with growth; depth of basal depression increasing with growth, calyx of 20mm diameter with flat base, those of more than 40mm diameter with marked depression. Radials hexagonal, in lateral contact with each other, distinctively shaped with narrow base against basals, widest point high up above midheight and upper suture concave against first primibrach.

A,B and E rays. First primibrach quadrate, wider than high, with convex sutural margins. Second primibrach pentagonal, relatively low, axillary, with convex sutural margins laterally, but gently concave above and below. First secundibrach variable in shape, usually 5-sided but may be 6-sided, with sutural margin directly against large first interprimibrach and horizontal upper margin.Second secundibrach usually lower than first but distinctly higher than succeeding arm plates, usually axillary and of highly variable shape. One arm on one specimen (AMF72536) with an axillary first secundibrach. Above the second secundibrach arms becoming biserial, composed of low wide irregularly shaped tertibrachs of which no more than 10 are evident in any one series on the material available. Articulation between brachials near base of tertibrach series (Fig. 24O) appears as an immovable symplexy, with four separate plates surrounding an elongate axial canal that is quite close to the surface on inner side of arm but separated from outside by thick plates; with a low wide transverse ridge evident just below outer end of axial canal; articular faces of brachials with fine well-developed radiating crenellae.

C and D rays. Only differences between these and A, B, and E rays are described in these two rays. First primibrach pentagonal, with extra angle against C–D interray; first secundibrach against C–D interray not abutting primanal but instead having sutural margin against large lateral secundanals. Some asymmetry usually evident with rays curving from C–D interray to some degree.

Interprimibrachs. Single interprimibrach at base 10-sided, as high as wide, with greatest width near top; having sutural margins of different lengths with basals, first and second primibrachs and first secundibrachs and supporting 2 interprimibrachs separated by a vertical suture in the second range, with one or three small plates in third range.

C–D interray. Large primanal 7-sided, in contact with basals and first primibrach and supporting 3 secundanals; tertanals 3 in number then successive rows of smaller less regularly arranged plates. Second primibrachs and first secundibrachs of C and D rays contacting secundanals rather than primanal.

Stem and free arms not available.

REMARKS

This species, represented by 6 calices in variable states of preservation, shows some variation between the small calyx (Fig. 24A– D) of 20mm diameter and the larger ones of over 40mm diameter; this variation has been expressed in the description above but also applies to the general shape which becomes more globular, to the tertibrachs which become less regular, to the upper interprimibrachs which become less numerous and to the basal depression which becomes more depressed.

Affinities have been discussed under the generic discussion above.

Subclass Inadunata
Order Disparida
Family Pisocrinidae Angelin, 1878

Parapisocrinus Mu, 1954

TYPE SPECIES

Pisocrinus ollula Angelin, 1878 from the Upper Silurian of Europe by original designation.

Parapisocrinus sp.
(Fig. 27K–M)

MATERIAL EXAMINED

QMF14842, a badly eroded calyx from UQL3579.

OCCURRENCE

Pragian, (*sulcatus* biozone), Martins Well Limestone Member of the Shield Creek Formation, near Martins Well, Pandanus Creek Station, north Queensland.

DESCRIPTION

Calyx small (7mm diameter), low, bowl-shaped, with wide deep basal depression; thick lateral walls spreading very gently upwards. Basal circlet of tiny plates situated entirely within the deeper part of the basal depression. Parts of three large plates (A and D radials and B inferradial) and three smaller plates (B, C and E radials) all defined clearly by typical pisocrinid suture pattern, but upper margin of cup badly eroded so that it is only evident on the B inferradial. Lumen of calyx occupying less than half its diameter.

REMARKS

This specimen is assigned on the basis of its pisocrinid suture pattern and the basal circlet being entirely confined to the basal depression. The incomplete nature of the calyx and generally poor state of preservation prevent specific assignment and useful comparison with other species. Bouska (1956) in discussing *Ollulocrinus* Bouska, 1956 (= *Parapisocrinus*) stated the generic features and alluded to the difficulty of identifying the sutures of the basal circlet. He assigned *Pisocrinus yassensis* Etheridge, 1904 from Yass, New South Wales to *Ollulocrinus* but that Late Silurian species is readily distinguished from the north Queensland Early Devonian specimen by the sharper rim to the basal depression and greater height to width ratio.

Order Cladida
Suborder Cyathocrinia
Family Gasterocomidae Roemer, 1854

Gasterocomid indet.
(Fig. 27A–H)

MATERIAL EXAMINED

QMF15152 and 15153, two badly weathered calices too poorly preserved for illustration or for definite identification. QMF14840 eight separate axillary brachial plates. All are from UQL3579.

OCCURRENCE

Pragian (*sulcatus* biozone), Martins Well Limestone Member of the Shield Creek Formation, near Martins Well, Pandanus Creek Station, north Queensland.

REMARKS

The calices are poorly preserved but QMF15152 does show one radial with a large but weathered articulatory surface pierced by a central canal and a circlet of 6 unequal plates at this level; unfortunately weathering has removed the base of the calyx and upper parts of the radials but what is preserved is consistent with *Arachnocrinus* Meek & Worthen, 1866 (see illustrations of Springer, 1911, pl. 2). The axillary brachials are close to those of *A. bulbosus* (Hall) (see Springer, 1911, pl. 2, figs 8,9) with Y-shaped canal on inner surface and isolated axial canal. Although this similarity is quite striking there is no guarantee that it is truely diagnostic. For the moment we prefer to leave the material in open nomenclature until better material is available to make a more positive identification.

Suborder Poteriocrinina
Family Cupressocrinitidae Roemer, 1854

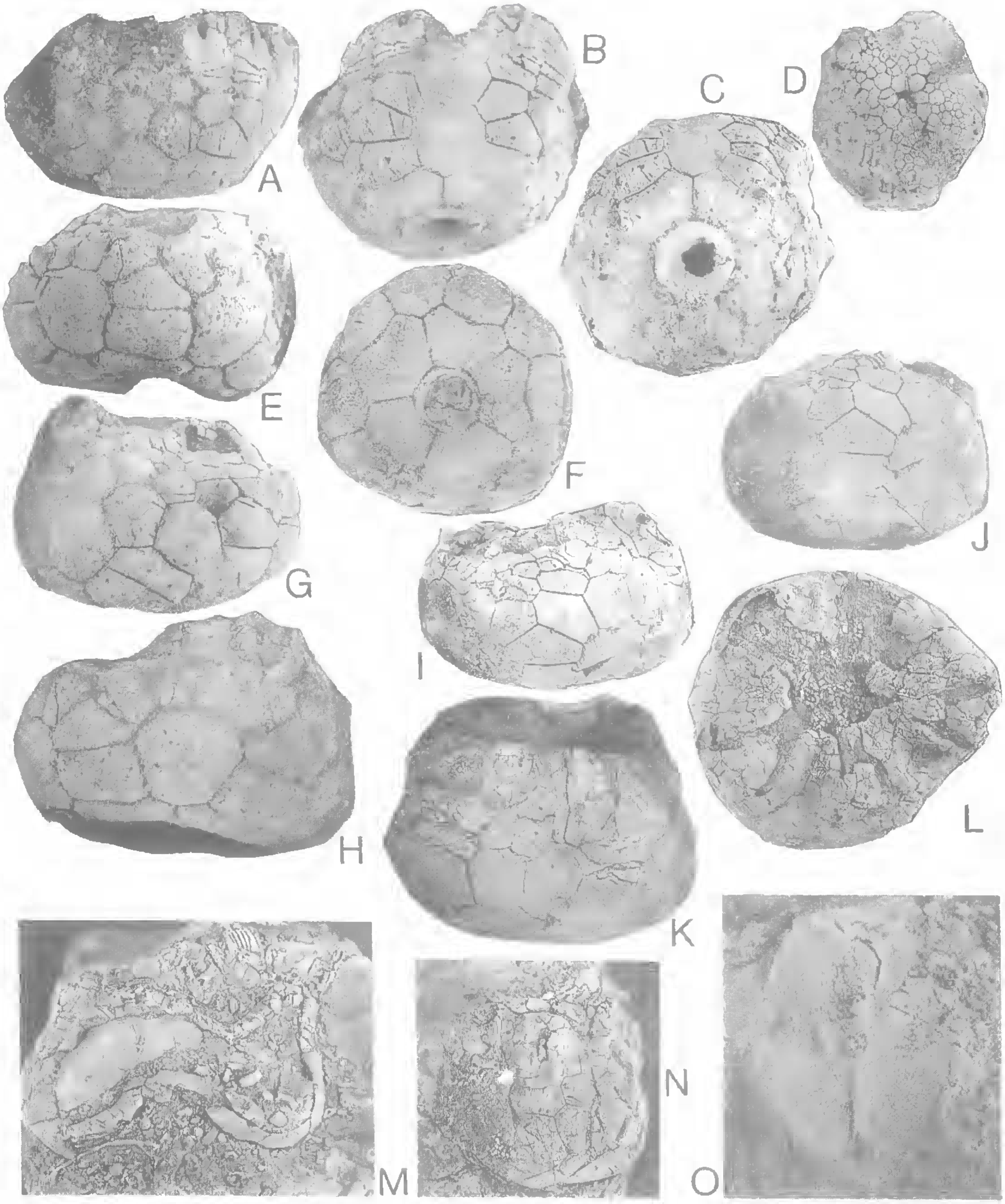


FIG. 24. *Shimantocrinus distinctodorsus* gen. et sp. nov. A–D, lateral in C–D interray, lateral in B–C interray, basal with C–B interray in 12 o'clock position and tegminal with A ray in 10 o'clock position views of small paratype calyx AMF72538, × 1.5, D × 1. E–H, lateral in B ray, basal with A ray at 3 o'clock, lateral in C–D interray and lateral in A–B interray views, respectively, of holotype calyx AMF72537, × 1. I–L, lateral in D ray, lateral oblique in D ray, lateral in C–D interray and tegminal with A ray at 4 o'clock views of large paratype calyx AMF72536, × 1. M,N, lateral views of natural section through paratype calyx and of D ray QMF14536, × 1. O, enlargement of articulatory face near base of free arm in B ray AMF72537, × 3.5.

Cupressocrinites Goldfuss, 1831

Type Species

Cupressocrinites crassus Goldfuss, 1831 from the Late Devonian of Germany; by subsequent designation of Wachsmuth & Springer (1886, p. 105).

Discussion

Cupressocrinites is a most distinctive genus (Moore, Strimple and Lane, 1978, p. 657) so that the Queensland material may be included with complete certainty. Distribution of the genus was restricted to Germany, Spain, Belgium and England (Moore, Strimple & Lane, 1978) until its recognition in Yunnan, China (Wang *et al.*, 1956), the Kuznetz Basin, and Urals, U.S.S.R. (Militsina, 1977) and now Queensland, Australia.

Cupressocrinites abbreviatus Goldfuss, 1839
(Fig. 26)

Material Examined

Holotype by monotypy the specimen figured by Goldfuss (1839, pl. 30, fig. 4), by Schultze (1867, pl. 2, fig. 1e) and by Moore, Strimple & Lane (1978, fig. 430, 2e).

Queensland Material

UQF75139 from UQL4440; UQF75140 and 75141 from UQL4443; UQF75142 from UQL5352; UQF75143–75148 from UQL5252; UQF75149–75151 from UQL5318; UQF75152 from UQL5364; UQF75153 from UQL5360; UQF75154 from UQL5285; UQF75155 from UQL4445; UQF75156 from UQL5220; UQF75157 from UQL5267; UQF75158 from UQL4441; UQF75159 and 75160 from UQL4442; UQF75161 from UQL5241; UQF75162 and 75163 from UQL4437; UQF75164 from UQL5372; QMF14582 from UQL5293; QMF14585 from UQL5348; QMF14586 from UQL5229; QMF14587–14589 from UQL5277; QMF14598, 14599, 14601, 14603 from UQL5356; QMF14868, 14873, 14875 from UQL5321. QMF14788 from float in the Burdekin River near Big Bend north of Charters Towers, north Queensland, probably derived from the Burdekin Formation.

Occurrence

Givetian, Papilio Formation, near Storm Dam, Wando Vale Station, north Queensland; Burdekin Formation, Burdekin River north of Charters Towers, north Queensland.

Description of Queensland Material

Fused infrabasals pentagonal to subrounded, appearing circular in more weathered specimens, with stem attachment including most of surface and exhibiting cruciform canal structure in stem. Five pentagonal basals each as high as wide, with gentle central convex bulge. Five low radials, twice as wide as high at maximum dimensions and these relative dimensions appear to be variable (e.g. the smaller specimens appear to have higher radials) Arms unbranched and highly modified to enclose a high conical space over the oral surface of the cup. First primibrach as wide as the radial but extremely low; subsequent primibrachs numbering three in the smallest individual (Fig. 26D,E) but up to nine on larger complete specimens. Primibrachs 2–4 each bear a broad central tubercle and display the vertical linear ornament near their lateral margins. On one specimen a brachial series is displaced laterally showing the considerable thickness of each plate and exposing a series of horizontal ridges and grooves on the sides of the brachials that would be in contact with adjacent brachials (Fig. 26C). Adoral surface poorly preserved; four similar flat almost petaloid orals, and one bifurcate posterior oral present; apertures clearly defined by them.

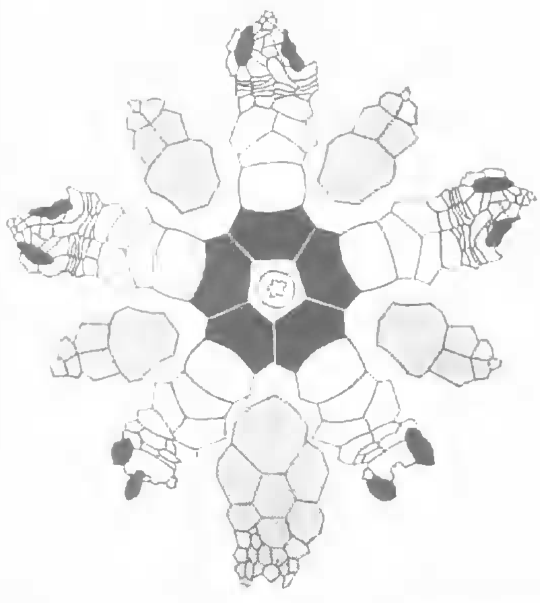
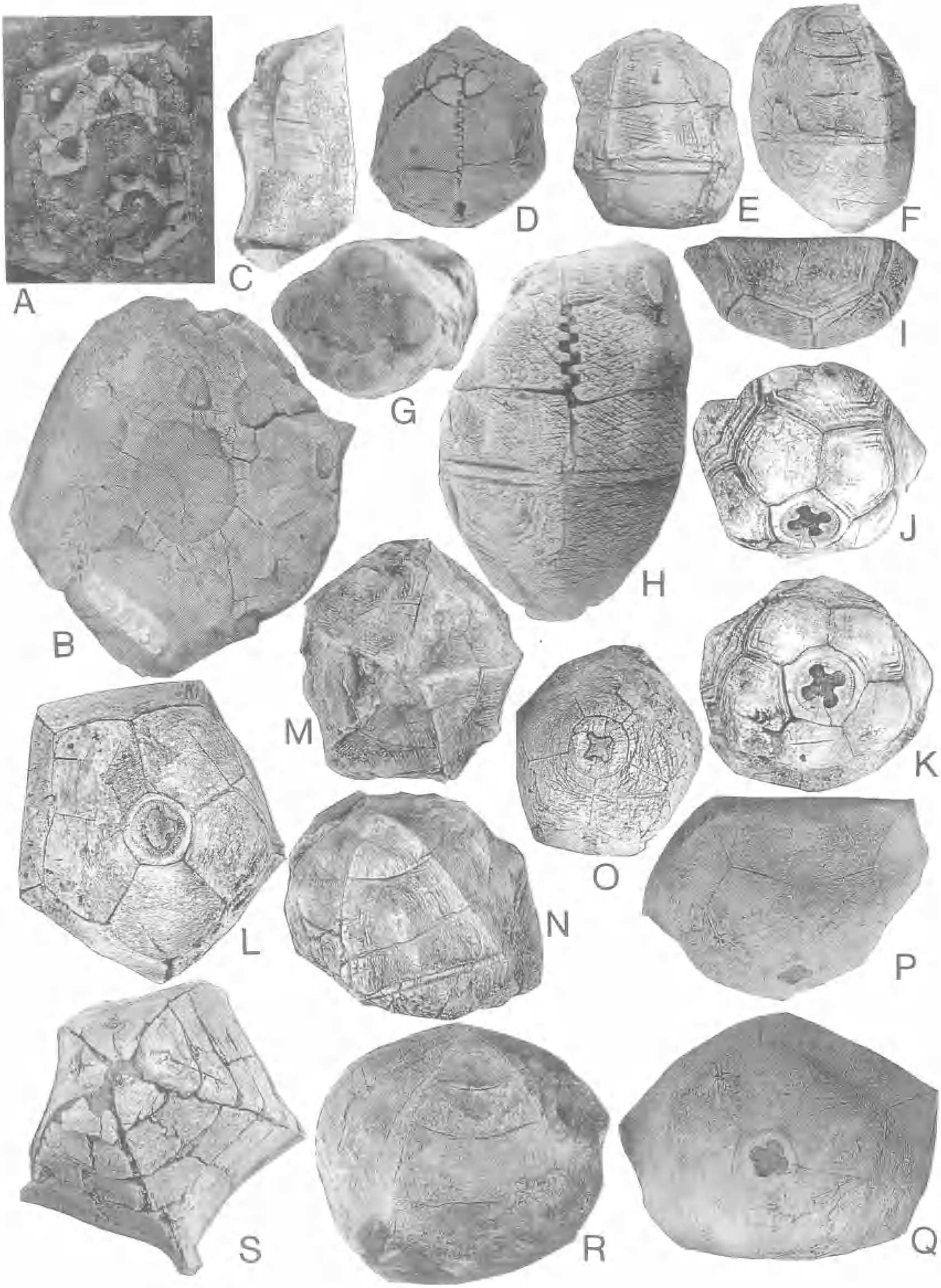


Fig. 25. Plate diagram of *Shimantocrinus distinctodorsus* gen. et sp. nov.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DISCUSSION

All specimens available from Queensland are weathered to some extent and most are incomplete, but collectively all the features of *C. abbreviatus* are displayed. A certain amount of variation in radial plate shape and in cup shape (from high cup-shaped to lower more bowl-shaped with increasing size) is evident in line with that exhibited by published illustrations of *C. abbreviatus* (Schultze, 1867, pl. 2). The largest specimen available bears a cemented radial holdfast structure on one of its basal plates with part of the holdfast extending across an interplate boundary suggesting that the attachment was made after the death of the host or at least after growth had ceased.

Cupressocrinites sp. cf. **C. gracilis** Goldfuss, 1831
(Fig. 27I,J)

MATERIAL EXAMINED

QMF14841, a weathered calyx from UQL3579.

OCCURRENCE

Pragian (*sulcatus* biozone), Martins Well Limestone Member of the Shield Creek Formation, near Martins Well on Pandanus Creek Station, north Queensland.

DESCRIPTION

Calyx small (approximately 8mm in diameter and 5mm high), low, with gently flaring sides; surface ornament unknown but apparently smooth. Infrabasal circlet not clearly exposed but low and evident in lateral view. Basals 5, as high as wide, with broadly convex lower margin. Radials much wider than high in lateral view, 5-sided, with radial canal aperture obvious on upper surface.

REMARKS

Although its radials are lower and squatter than those in *C. gracilis* this individual is well within the range of variation in calical shape exhibited by this species (Schultze, 1867, pl. 3, fig. 2, 2a–g). As far as observed, the plate arrangement is identical and the upper surface of the calyx with conspicuous openings situated centrally in each radial plate is identical. Small columnals (e.g. QMF14841b) with four lateral canals around a larger central canal and characteristic of *Cupressocrinites* are found at this locality. The fact that some of the cup is not observable makes certain specific assignment impossible. It should be noted in passing that *C. assimilis* Dubatolova, 1964 is almost certainly a synonym of *C. gracilis*.

Inadunate indet.
(Fig. 27R)

MATERIAL EXAMINED

AMF72551, a slightly disarticulated calyx, silicified and naturally weathered from a dark bioclastic limestone horizon GCR283 (see Mawson *et al.* (1988).

OCCURRENCE

Pragian (*sulcatus* biozone), Garra Formation, near Wellington, central New South Wales.

DESCRIPTION

Calyx small, 5mm high, flaring only very gently upwards. Infrabasals extremely low, but visible laterally. Basals hexagonal but base almost horizontal, five in number. Radials largest plates in cup, 5-sided, as high as wide, with broadly concave upper margin. First primibrach quadrangular, convex below, transverse above, wider than high, as wide as radial. Second primibrach axillary, 5-sided, wider than

FIG. 26. *Cupressocrinites abbreviatus* Goldfuss, 1839. A,B, adoral views of damaged calices without arms, UQF75162, × 1 and QMF14873, × 1.5, respectively. C, lateral view of arm of a small crown showing horizontal grooves, UQF75150, × 1.5. D,E, adoral and lateral views of small crown QMF14868, × 2. F, lateral view of small crown UQF75149, × 1. G, end view of section of stem showing central canal and 4 peripheral canals QMF14856, × 4. H, lateral view of small crown QMF14740, × 2. I,L, lateral and aboral views of calyx, UQF75159, × 1.5. J,K, lateral oblique and aboral views of small calyx UQF14588, × 2. M,N, adoral and oblique views of damaged crown UQF75164, × 1.5. O, aboral view of large calyx UQF75145, × 0.6. P,Q, lateral and aboral views of large calyx showing a weathered attachment base of another crinoid on radial plate UQF75143, × 0.75. R, oblique view of upper part of large crown QMF14589, × 1. S, Adoral view of incomplete crown found as float in bed of Burdekin River just north of Charters Towers in vicinity of Big Bend, QMF14788, × 2.

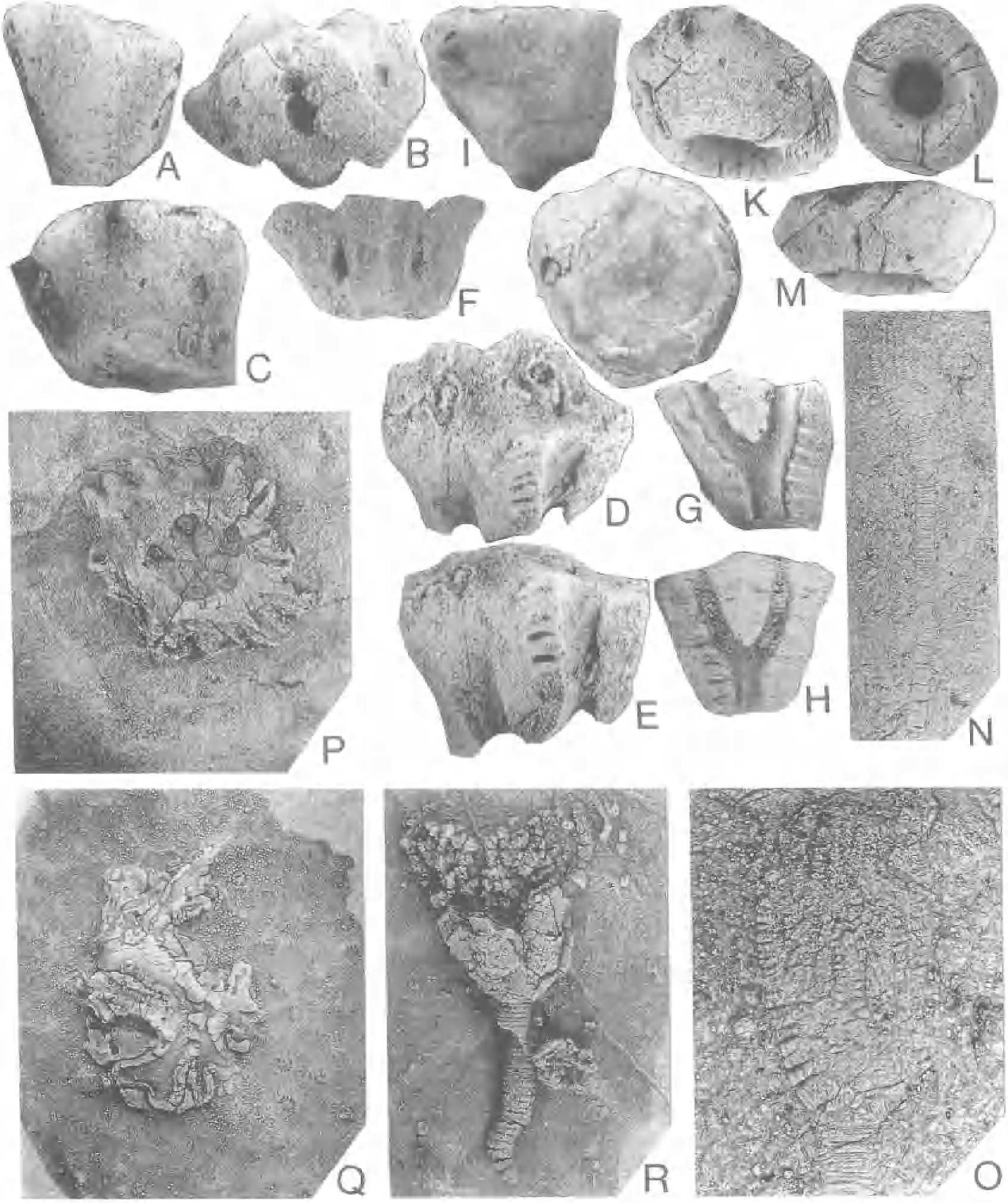

FIG. 27. A–H, Gasterocomid axillary brachials. A, lateral view QMF14840A, × 3. B–E, lower, lateral, adoral oblique and adoral views of plate QMF14840B, × 5. F,G, adoral and inner lateral views of plate QMG14840C, × 4. H,inner lateral view of plate QMF14840D, × 4. I,J, *Cupressocrinites* sp. cf. *C. gracilis* Goldfuss, 1831, lateral and adoral views of small poorly preserved calyx QMF14841, × 3. K–M, *Parapisocrinus* sp. lateral oblique, aboral and lateral views of small damaged calyx QMF14842, × 3. N,O, Crinoid indet. 2 JCF11361, × 0.8 and × 1.7, respectively. P,Q, crinoid attachment bases on heliolitid coral colonies from UQL5318, QMF14858 and 14859, × 2. R, Crinoid indet. 1. AMF72551, × 2.2.

high, as wide as first primibrach. Secundibrachs 3 in number, 3rd axillary, uniserial. Subsequent brachials indistinct but apparently uniserial. Anal plates not evident. Stem circular, of simple low discs each approximately 0.5mm high.

REMARKS

This specimen may be identified as an inadunate by the lack of interbrachials and lack of fixed brachials.

Crinoid Indet. 1
(Fig. 7A–F)

MATERIAL EXAMINED

QMF14591 a large, poorly preserved calyx. Associated large stem fragments QMF14592–14594 are consistent in size although this may not always be the best guide (Franzen-Bengtson, 1982). All are from QML547 (=UQL5209).

OCCURRENCE

Late Emsian or Eifelian, Burges Formation, just west of Broken River Gorge, Wando Vale Station, north Queensland.

REMARKS

The large calyx (60mm diameter × 25mm high) has a wide deep basal depression and although some plates are evident in several areas we were unable to determine any regular pattern to allow identification. Its inclusion here is because of the structure exhibited by associated stem fragments and its association with the indeterminate carpocrinid (Fig.7G-J, 8). Individual ossicles in the stem are pierced by canals that are expressed at the lateral surface by prominent tubercles which are seen to be aligned in vertical columns. The axial canal is relatively small being similar in proportion to that of the large stem figured by Franzen-Bengtson (1982, fig. 1B) but the radial canals in the Australian specimen are straight, unbranched and fewer.

Crinoid indet. 2
(Fig. 27N,O)

MATERIAL EXAMINED

JCF11361, a weathered individual from the Hervey Range.

OCCURRENCE

Givetian, Burdekin Formation at 441558 on the Townsville 1:250000 Geological Sheet in the Hervey Range.

REMARKS

This individual with a crown some 30mm high and 60mm of stem attached is exposed on the surface of a coarse bioclastic limestone and has weathered at the same rate as the matrix so that virtually only a section of the animal remains. However, several arms are evident so that the plane exposed must fortuitously be close to one side of the crown. Unfortunately the calyx is not well enough exposed for identification.

The calyx is 4 or 5 plates high but their identity is uncertain. The arms appear to be unbranched, biserial and highly pinnulate. The stem consists of a large number of very low columnals apparently alternating in height in some sections between higher and lower columnals. The significance of this specimen is that it demonstrates an as yet unknown crinoid fauna in sediments of the Burdekin Shelf. Together with the partial crown of *Cupressocrinites abbreviatus* found as float in the Burdekin River (Fig. 26S) this specimen represents all that is known to the authors at present of the crinoid fauna from the Burdekin Basin.

Crinoid attachment bases
(Fig. 27P,Q)

MATERIAL EXAMINED

QMF14859, 14860 and numerous unregistered specimens from numerous localities.

OCCURRENCE

Late Eifelian and Givetian, Papilio Formation in the vicinity of Storm Dam, Wando Vale Station, north Queensland.

REMARKS

These holdfasts may be classified on the scheme of Brett (1980) as Simple Discoidal Holdfasts in different stages of weathering and one (Fig. 27P) shows peripheral canals running down into the holdfast. Brett (1980, p. 356, fig. 6A) pointed out that *Cupressocrinites abbreviatus* has this type of terminal holdfast. As that species is very common in the same localities these holdfasts probably belong to it. A variety of other holfasts are known through this formation but a detailed study is outside the scope of this paper. Similarly, numerous different stem types are present at these localities but we have not studied them in detail.

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APPENDIX

Grid references given in square brackets refer to the following 1:100000 topographic maps: Burges (sheet No. 7859), Dubbo (8633), Mansfield (8123), Ridgelands (8951), Wando Valc (7858), Wellington (8632).

NORTH QUEENSLAND

Upper Martin's Well Limestone Member, Shield Creek Formation. Early Devonian, early Pragian, *sulcatus* conodont biozone. All localities are in the vicinity of Martins Well, 8km east of Pandanus Creek Homestead. 200km northwest of Charters Towers.

UQL2498 Burges [683683] upper part of limestone 70m east of Martins Well windmill. *Pandanocrinus martinswellensis.*

UQL2710 Burges [675680] westernmost outcrop of limestone 1km west of Martins Well Windmill. *Pandanocrinus martinswellensis.*

UQL3577, 3578, 3579, 3580, 4058 Burges [687683] five localities collected from east to west along thc fence line 600m east of Martins Well windmill; all from upper part of limestone that is slightly folded in this area so that sequence is not strictly stratigraphic. *Pandanocrinus martinswellensis* (markedly abundant), *Parapisocrinus* sp., Gasterocomid indet. *Cupressocrinites* sp. cf. *C. gracilis.*

Shield Creek Formation. Early Devonian, early Pragian, *sulcatus* conodont biozone.

UQL3574 Burges [617712] detrital limestone bed on eastern slope of ridge 7.3km north of Old Pandanus Creek Homestead, 200km northwest of

Charters Towers. *Eucalyptocrinites praerosaceus, Pandanocrinus martinswellensis.*

Burges Formation, Broken River Group. Early Middle Devonian, late Emsian to Givetian.

UQL5209 (=QML547) Burges [648459], prominent limestone knoll on left bank 100m from mouth of 2nd left bank side creek upstream from Jack Hills Gorge on the Broken River, Wando Vale Station, 150km northwest of Charters Towers. Carpocrinid indet.

UQL5372 Burges [691535], 20m above Jessey Springs Limestone in New Chum Gully, east of Jessey Springs Hut, Wade Holding, 200km northwest of Charters Towers. Givetian (*varcus* biozone. *Cupressocrinites abbreviatus.*

Dosey Limestone, Broken River Group. Middle Devonian, Eifelian to early Givetian.

UQL5234 Wando Vale [577394], very low in Dosey Limestone on southeast flank of the Dosey syncline 2.6km northeast of Storm Dam, Wando Vale Station, 150km northwest of Charters Towers; no older than *costatus* biozone, Eifelian. *Hexacrinites interscapularis.*

Papilio Formation, Broken River Group. Middle Devonian, late Emsian to Givetian, *kockelianus* to *varcus* conodont biozones. All localities in the Storm Dam area, north of Dosey Outstation to Six Mile Dam north of Broken River, Wando Vale Station, 150km northwest of Charters Towers.

UQL4427 Burges [597444], limestone rubble 300m north of Broken River, southwest of old Six Mile Yard. *Hexacrinities interscapularis, Rhipidocrinus* indet.

UQL4437 Wando Vale [545365], on terrace edge on south side of creek junction, 1.5km southwest of Storm Dam; *varcus* biozone, Givetian. *C. abbreviatus.*

UQL4440 Wando Vale [543364] in gully 200m upstream from UQL4437; *varcus* biozone, Givetian. *C. abbreviatus.*

UQL4441 Wando Vale [543364] 20m south of UQL4440; *varcus* biozone, Givetian. *C. abbreviatus.*

UQL4442 Wando Vale [544367] shallow gully 1.4km southwest of Storm Dam; not younger than *ensensis* biozone, late Eifelian or early Givetian. *C. abbreviatus, Hexacrinites interscapularis.*

UQL4443 Wando Vale [544367] 60m up gully from UQL4442; similar horizon to UQL4442. *C. abbreviatus, Melocrinites tempestus.*

UQL4445 Wando Vale [543366] 220m up gully from UQL4443; similar horizon to UQL4442.

UQL4447 Wando Vale [547366] 80m up gully from UQL4445; similar horizon to UQL4442. *C. abbreviatus.*

UQL5218 Wando Vale [559389] approximately 68m above base of formation in gully on east slope of Storm Hill, 1.2km north of Storm Dam; ?late Eifelian. *Melocrinites tempestus.*

UQL5220 Wando Vale [559398] basal 2m of formation 1km north of Storm Hill; ? late Eifelian. *C. abbreviatus.*

UQL5227 Wando Vale [574376] 20–30m above base of formation on left flank of gully flowing into Dosey Creek 2km east of Storm Dam; ?late Eifelian. *Hexacrinites interscapularis.*

UQL5228 Wando Vale [574375] 70–120m above base of formation on right flank of same gully as UQL5227; same horizon as UQL5227. *H. interscapularis.*

UQL5229 Wando Vale [560371] right bank of Storm Dam Creek about 50m upstream from the confluence with the gully into which Storm Dam overflows when filled; *varcus* biozone, Givetian. *Rhipidocrinus crenatus, C. abbreviatus.*

UQL5231 Wando Vale [558368] high in the formation on the crest of hill 800m southeast of Storm Dam; *varcus* biozone, Givetian.

UQL5241 Wando Vale [563371] high in the formation on the right flank of Storm Dam Creek; *varcus* biozone, Givetian. *C. abbreviatus.*

UQL5243 Wando Vale [563370] high in the formation on Storm Dam Creek 50m south of UQL5241; *varcus* biozone, Givetian.

UQL5252 Wando Vale [551366] south flank of low hill 1km south of Storm Dam; ?*varcus* biozone, Givetian. *C. abbreviatus, H. interscapularis.*

UQL5254 Wando Vale [544367] shallow gully 1.4km southwest of Storm Dam; not younger than *ensensis* biozone, late Eifelian or early Givetian.

UQL5257 Wando Vale [558386] high in the formation at top of hill 800m north northeast of Storm Dam; not older than middle *varcus* biozone, Givetian. *H. spinosus.*

UQL5267 Wando Vale [543363] in gully 1.5km southwest of Storm Dam; no older than UQL5257. *H. interscapularis.*

UQL5268 Wando Vale [542362] 100m southwest of UQL5267; same biozone as UQL5267 but slightly above it, Givetian.

UQL5269 Wando Vale [543364] gully 200m upstream from UQL5267; approximately same horizon as UQL5267.

UQL5272 Wando Vale [536360] on open ground 300m east of UQL5358; no older than *varcus* biozone, Givetian. *Rhipidocrinus*? sp.

UQL5277 Wando Vale [570409] 51–56m above base of section 300m east southeast of The Volcano; assumed early Givetian. *C. abbreviatus, Dolatocrinus peregrinus, H. spinosus.*

UQL5284 Wando Vale [539359.5] eroded area on crest of low divide, on eastward extension of the north arm of The Spanner; middle *varcus* biozone, Givetian.

UQL5285 Wando Vale [539359.5] on left flank of small gully just northwest of eroded area on crest of low divide on eastward extension of the north arm of the Spanner; middle *varcus* biozone. *C. abbreviatus.*

UQL5293 Wando Vale [524369] gully 400m east of the divide between Dosey and Page Creeks; ?Givetian. *C. abbreviatus.*

UQL5305 Wando Vale [569404] southwesterly oriented gully 400m south of the Volcano; not older than *varcus* biozone. *H. interscapularis.*

UQL5317 Wando Vale [564394.5] 9m above the base of the formation 2km northeast of Storm Dam; late Eifelian of early Givetian. *H. interscapularis, H. spinosus.*

UQL5318 Wando Vale [565395] 65–116m above base of formation in gully 2.2km northeast of Storm Dam; no older than *ensensis* biozone. *Rhipidocrinus crenatus, C. abbreviatus, H. interscapularis, Melocrinites tempestus.*

UQL5320 Wando Vale [563392] section on ridge 2.9km northeast of Storm Dam; late Eifelian — Givetian. *Hexacrinites interscapularis, Cupressocrinites abbreviatus, Rhipidocrinus crenatus, Dolatocrinus peregrinus.*

UQL5321 Wando Vale [562390] creek section 3km northeast of Storm Dam; late Eifelian — Givetian. *Hexacrinites interscapularis, Cupressocrinites abbreviatus, Rhipidocrinus crenatus, Dolatocrinus peregrinus.*

UQL5352 Wando Vale [581409] 66.7m above base of formation in gully 900m northeast of where Papilio Creek emerges from the Storm Hill Sandstone; late Eifelian or early Givetian. *C. abbreviatus.*

UQL5356 Wando Vale [554367] east flank of Spongophyllum Hill, in head of eroding gully; *varcus* biozone, Givetian. *H. interscapularis, Melocrinites tempestus, Rhipidocrinus crenatus.*

UQL5358 Wando Vale [533360] small gully slightly north of west of low divide formed from extension of the north arm of the Spanner; middle *varcus* biozone, Givetian. *C. abbreviatus.*

UQL5360 Wando Vale [566374] eroding head of gully tributary to Storm Dam Creek; Givetian, no older than *varcus* biozone. *H. interscapularis, C. abbreviatus.*

UQL5364 Wando Vale [551366] low in the formation on south flank of hill 1km south of Storm Dam; Givetian, probably *varcus* biozone. *C. abbreviatus.*

Burdekin limestone, Fanning River Group. Middle Devonian, Eifelian to Givetian.

Float in bed of Burdekin River near Big Bend, north of Charters Towers; Givetian. *Cupressocrinites abbreviatus.*

Hervey Range, at [441558] on Townsville 1:250000 Geological Sheet; Givetian. Crinoid indet. 2.

CENTRAL QUEENSLAND

Mount Holly Beds. ?Lochkovian to Pragian.

UQL3522 Ridgelands [396367] base of north slope of Mount Etna, 30kmnorth of Rockhampton, central Queensland. *Pandanocrinus* sp. cf. *P. wellingtonensis.*

CENTRAL NEW SOUTH WALES

Garra Formation. Early Devonian, late Lochkovian to Pragian.

QML512 Wellington [799867] richly fossiliferous limestone (Unit 18 of Johnson, 1975) 870m NNW of Mountain View Homestead on Wellington Caves Road, 9km SSW of Wellington, N.S.W.; apparently *sulcatus* biozone. Spyridiocrinid gen. et sp. nov., *Struszocrinus dulciculus, Ctenocrinus solus, Eucalyptocrinites rosaceus, Shimantocrinus distinctodorsus, Pandanocrinus wellingtonensis.*

NMVPL1957 Dubbo [729135] richly fossiliferous limestone on west side of an abandoned quarry on southwestern edge of Geurie between Dubbo and Wellington; presumed Pragian. *Pandanocrinus gueriensis.*

NMVPL1958 Wellington [761013] coralline limestone on hillside immediately southeast of Macquarie Park Homestead, 8km northwest of Wellington; presumed Pragian. Polypeltid indet.

GCR283 at 281.9m above base of stratigraphic section 300m south southeast of Wellington Caves office (see Mawson *et al.* in press, fig. 6, Table 2).

CENTRAL VICTORIA

Loyola Limestone, Norton Gully Sandstone. Early Devonian, Pragian (*kindlei* biozone).

Griffith's Quarry 11km southwest of Mansfield, 200km northeast of Melbourne, Victoria. Mansfield 1:100000 sheet [135904] *Eucalyptocrinites fonzi.*